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SPE JOURNAL

The Official Publication of the Society of Plastics Engineers, Inc.

EDITORIAL DEPT.
UNIVERSITY MICROFILMS, INC.
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ANN ARBOR, MICH.
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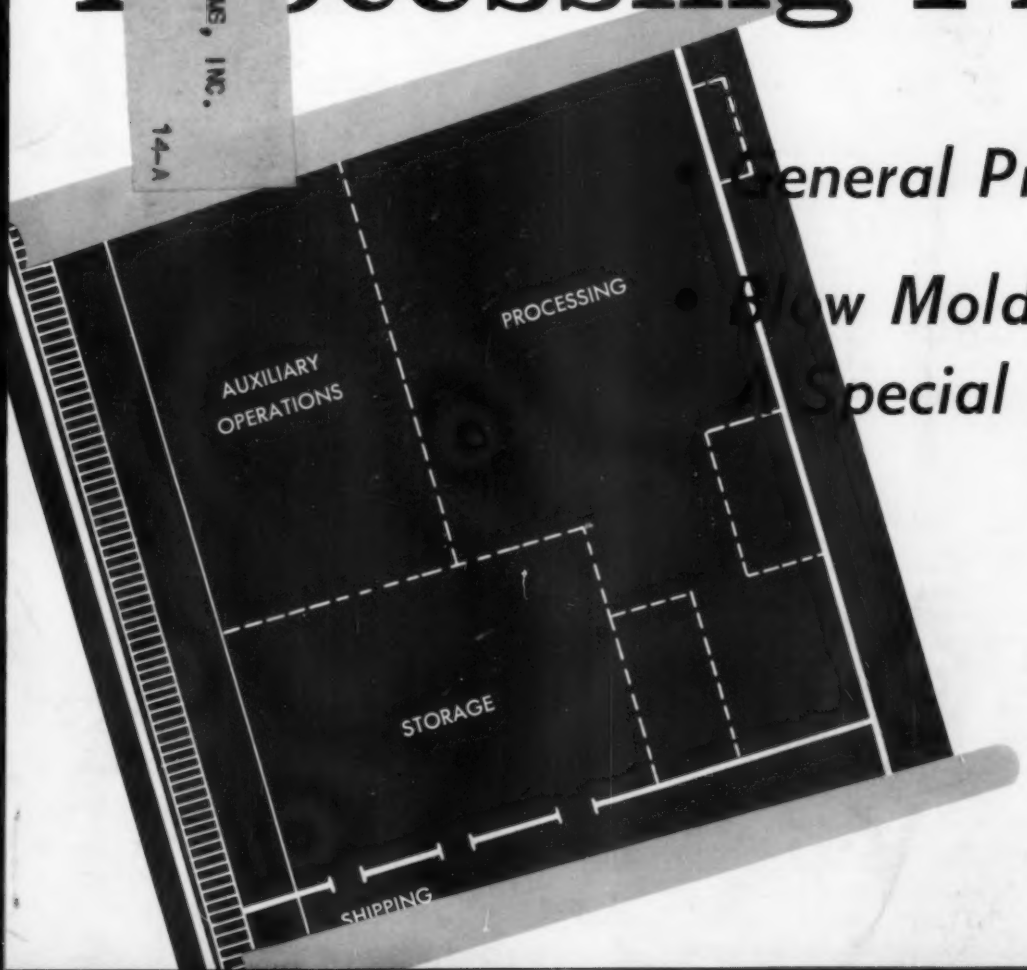
Planning the Processing Plant

- General Principles
- Blow Molding—A Special Situation



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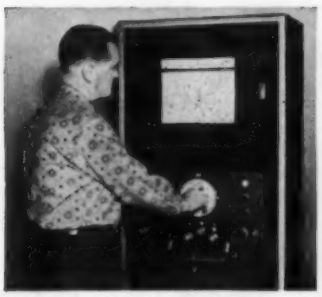

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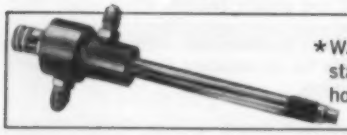

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SPE JOURNAL

Cover:
For details of the plant shell shown on the cover, see page 1161

SPE Journal Newsletter 1147

REGIONAL TECHNICAL CONFERENCES

Screw Injection Molding, December 1, 1961, sponsored by the Cleveland Section
Papers on all aspects of this new molding technology 1153

Plastics Foams Progress
New developments in foams presented at the Buffalo RETEC 1154

Special Feature

Establishing the Successful Plastics Processing Plant
Richard S. DeBell, DeBell and Richardson, Inc., and Melvyn A. Kohudic, Editor, SPE Journal
A blueprint for design, operation and distribution with specific emphasis on blow molding 1159

SPE Journal Features

Speaking of Extrusion—Thickness Measurement of Extruded Film
George Gerhard, Industrial Nucleonics Corp.
Isotopes for continuous, non-contacting measurement 1173

Reinforced Plastics—Materials Design Handbook for Aerospace Vehicles
C. S. Grove, Jr. and R. Ford Pray, III, Syracuse University
Plan for a reinforced plastics literature research project 1182

Moldmaking—Five New Parts for Better Molds
C. E. Ballentine, Scripto Inc.
New auxiliary parts simplify mold design procedures 1187

Technical Articles

A New Catalyst for Urethane Foams
H. Stone, E. A. Dickert and J. S. Dunwoodie, Allied Chemical Corp.
A new stable catalyst for resilient foams 1199

Hardness of Polymeric Materials
Eric Baer, University of Illinois, and A. E. Maier, and R. N. Peterson
E. I. du Pont de Nemours & Co.
Results of hardness tests interpreted in terms of stress-strain behavior 1203

Thermal Stability of Silicone Resins Containing p-Phenylenedisilanes
L. W. Breed, Midwest Research Institute
Elevated temperature stability of silicone resins improved 1206

Comparison of Spiral-Cavity Mold Flow with Laboratory Scale Flow Tests on Thermoplastics
J. J. Gouza and G. G. Freygang, Rohm & Haas Co.
How flow data can be correlated from laboratory tests 1211

News of SPE

Society Action—SPE New Officers for 1962 1218

Departments

Editorial 1139
Letters to the Editor 1143
Section News 1221
Technical Meetings 1224
Book Reviews 1228
Plastics Around the World 1230
About Members 1232
New Equipment and Materials 1238
Employment and Service Guide 1243
Advertisers' Index 1246

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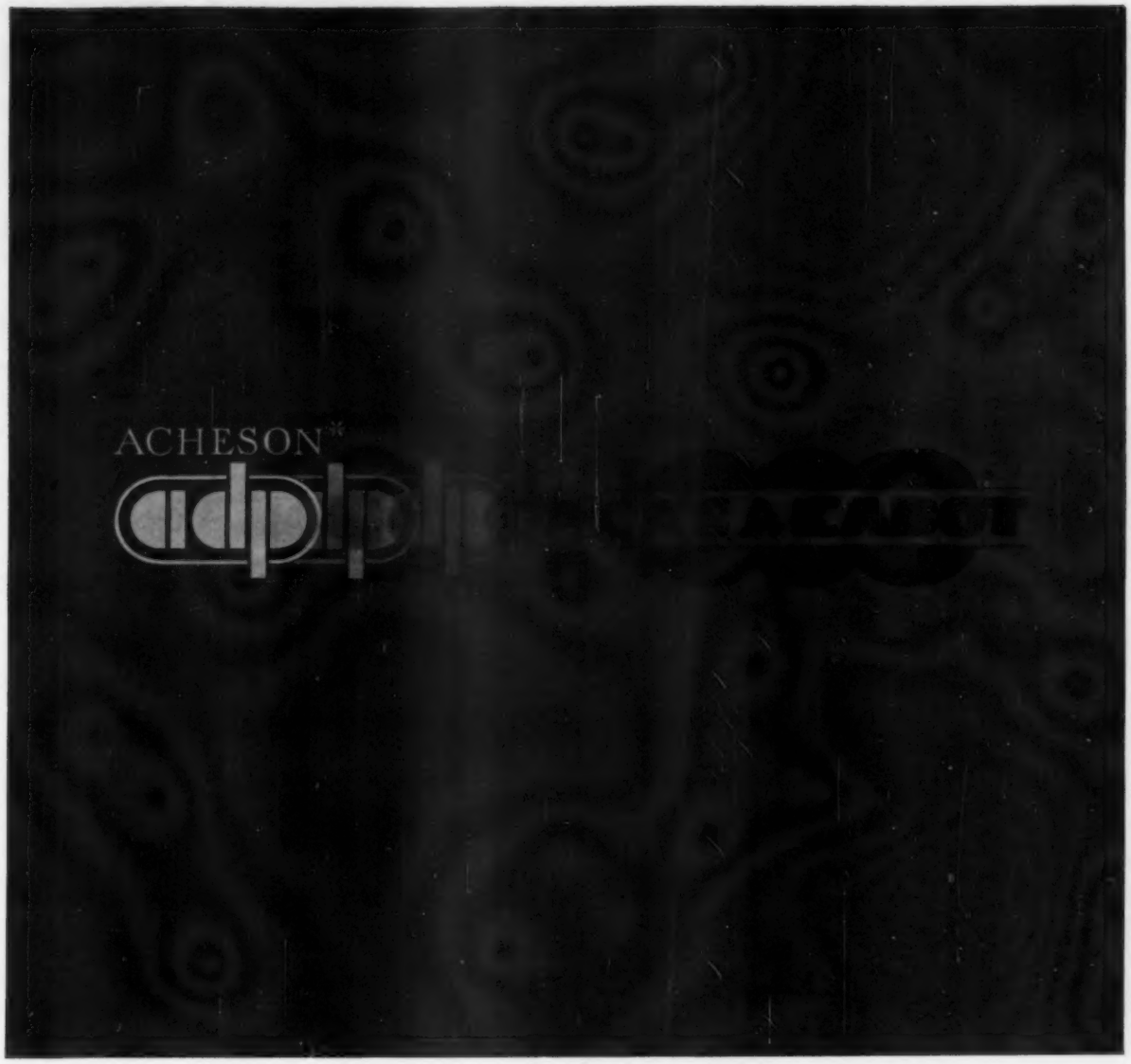

Acheson Dispersed Pigments Company, one of the most trusted names in the dispersion field, has just been acquired by Cabot Corporation, internationally known as a producer of carbon black and other chemicals for industry. ADP is now the Acheson Dispersed Pigments Division of Cabot Corp., but will continue to mix and disperse all types of pigments, colors, antioxidants, and other additives in the entire range of resins, polymers and liquids.

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• ***No interruption of service.*** The entire operating staff of ADP is being kept so that you can maintain the contacts you have established, and continue to have the benefit of their know-how and experience. As before, you may specify the source of supply for all materials.

• ***Increased service.*** Cabot brings to this new division extensive, world-wide research and development, production, and distribution facilities. Combining these with Acheson's makes it possible to serve your needs better for high quality dispersions.

• ***More and better products from Cabot.*** The acquisition enables Cabot to offer present products in new forms, and to provide altogether new products which will require mixing and dispersing.

• ***Commercial development of CAB-XL®.*** Cabot now will explore commercial possibilities for its crosslinkable polyethylene compounds presently being marketed under the name of CAB-XL® compounds.

Cabot looks forward to helping you with your dispersion problems.

**Only Acheson Dispersed Pigments Company has been acquired by Cabot. Acheson Industries, Inc., a leading supplier of liquid colloidal dispersions, continues to own and operate plants at Port Huron, Michigan, U.S.A., Plymouth, England, and Scheemda, The Netherlands.*

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EDITORIAL

The Revolution over a Bottle

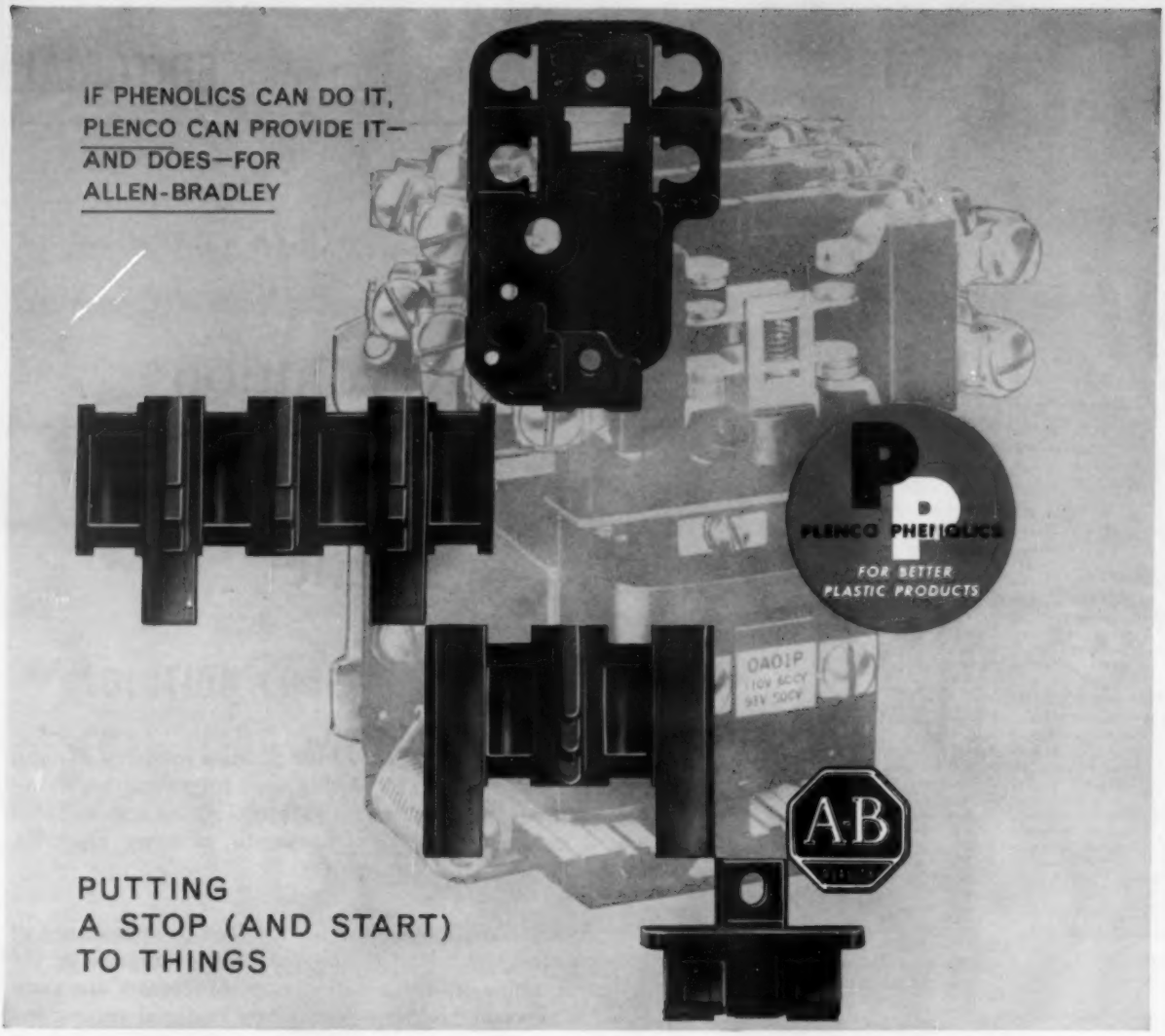
A swift revolution is taking place in the plastics industry. Behind it all: The plastics bottle. Currently being used for packaging liquid detergents, bleach, and other household chemicals, the blow-molded containers will gradually take over packaging of other products, such as catsup, carbonated beverages.

One of the most striking changes evident is the disappearance of the plastics processing industry as the old timers (anyone in the business 5 years) know it. The small custom processors are gone. In their place have come the large packaging material companies, already with a big stake in the container field. Giant, custom-built blow molding machines in satellite plants use resin by the carload (see this month's Special Feature, page 1159).

This processing picture is far from static. And with the stakes so high, resin manufacturers must weigh carefully every production and marketing move they make. Should marketing emphasis be in the area of the end user, for example the detergent manufacturer, or the processor? In this fast-changing field, the wrong decision here can affect a company's fortunes for years to come.

Complicating the picture for both the resin manufacturer and the big processors is the fact that many of the companies now using blown plastic bottles may become processors themselves.

Nothing has so excited the imagination of the plastics industry as the blow molding process; nothing in recent history has surpassed the resulting challenge that companies must meet if they are to succeed.



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It is one of an unusually extensive variety of both general- and special-purpose Plenco molding compounds . . . ready-made or custom-formulated to your needs. Carefully controlled through every phase of their production, Plenco phenolics have long passed the most critical tests of industry. We'd like the opportunity to pass *yours.*

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U.S.I. POLYETHYLENE NEWS

A series of advertisements for plastics and packaging executives by the makers of PETROTHENE® polyethylene resins

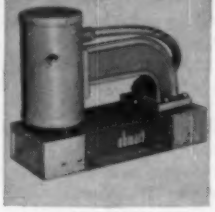
Packaging Notes

Laundry-grade polyethylene film is offered along with a choice of two sealing

units and a promotional kit to spur sales. This ultra-clear customized wrap, designed to replace kraft paper, boxes or cellophane, provides such advantages as: fast, foolproof inspection; increased sales appeal; all-weather protection.

CIRCLE ③ ON COUPON

Nuclear thickness gauge using beta radiation is currently available in a new small size. Measuring only 22 inches long and believed to be the simplest of its type, it will indicate or record thicknesses of sheet materials up to 12 inches wide. Unit is described as "relatively inexpensive . . . extremely useful in the laboratory determination of thickness or density of plastic films, paper, coated materials, and metal foils."

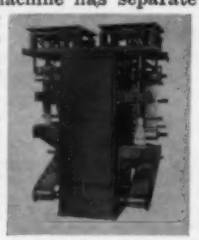


CIRCLE ④ ON COUPON

Diet bar, a new baked dietary food product, is packaged in carbon-dioxide atmosphere in a foil-and-polyethylene wrapper. Standard flavors are chocolate, lemon and spice. Three bars daily reportedly provide 1,248 calories.

CIRCLE ⑤ ON COUPON

New "form and fill" machine packages candies and IQF foods in polyethylene at speeds up to 150 units per minute. This double-tube machine has separate drives, permitting either of the two tubes to be operated independently of the other. It produces packages ranging in size from 2" x 3" to 8" x 14⅛" and handles polyethylene film or polyethylene coated substrates.



CIRCLE ⑥ ON COUPON

Polyethylene Uniquely Qualified For Nuclear Applications

As a Secondary Neutron Shielding Material, It's Unparalleled In Efficiency

There's no dearth of jobs for polyethylene in the nuclear field. It's the lightest of all materials effective against neutrons and, as such, is uniquely suited for use where space and weight are at a premium. In nuclear-powered ships, submarines and yet-to-be-built planes, for example, polyethylene plate is considered the ideal secondary neutron shielding material.

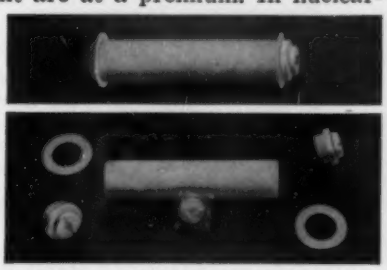
Why It Works

Polyethylene's effectiveness in nuclear operations lies in its ability to slow down the highly penetrating, fast moving, erratic neutrons. The best way to do this, it has been found, is to present a high concentration of light atoms as a barrier to their movement. Since hydrogen is the lightest atom, polyethylene, possessing four hydrogen atoms per monomer unit, has this capacity.

In addition, polyethylene offers: sufficient temperature resistance for most shielding applications; good dimensional stability and form retention; resistance to abrasion and impact; compatibility with other materials. It's also easy and economical to machine. And, it will not give off noxious gases in the event of fire.

Poundage Adds Up

While the number of reactor units is a limiting factor in the market for polyethylene shielding, individual installations do show large-scale use on a poundage basis. For instance, each nuclear submarine built today carries from 55,000 to 60,000 lbs. of polyethylene shielding; the merchant ship N.S. Savannah, 250,000 lbs.; and the guided missile cruiser U.S.S. Long Beach, 500,000 lbs. All of which puts the annual requirement of polyethylene sheet for shielding between 1½ and 2 million pounds!



Polyethylene "rabbit" houses chemicals to be irradiated as part of U.S.I.-sponsored nuclear research. Company's PETROTHENE resins are used to make reactor shielding for atomic powered vessels.

U. S. I. Spurs Use

Reactor shielding is only one way polyethylene participates in nuclear progress. Its applications at the Industrial Reactor Laboratories, Plainsboro, N. J., are typical. This facility is jointly owned by National Distillers and Chemical Corp.'s U.S. Industrial Chemicals Co. division and nine other companies which conduct radiation research related to their particular products.

Here, polyethylene containers known as "rabbits" transport test specimens through pneumatic tubes in and out of specific reactor zones. Polyethylene film protects materials and instruments from radioactive dusts. Polyethylene-coated paper protects floors against contamination. A polyethylene film sleeve encases and protects the mechanical arm of a hot cell manipulator at all times.

CIRCLE ① ON COUPON

Polyethylene Window Posters Fold Down to Envelope Size

Open — it's a colorful 3' x 3' sign ready for posting; closed — it fits into a 10" x 12" envelope. And, because it's of lightweight flexibile polyethylene film, this window display piece can be mailed without stiffener at very low cost. A New Jersey firm designs and produces the small billboards in sizes up to 72" x 72".

CIRCLE ② ON COUPON

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POLYETHYLENE PROCESSING TIPS

ELIMINATING EXCESSIVE BLOCKING IN POLYETHYLENE FILMS AND COATED SUBSTRATES

Blocking – the tendency of a film or coated substrate to adhere to itself or, in some cases, to another surface – plagues many polyethylene extruders and converters. Yet even where blocking is excessive, it can be eliminated in most cases.

Slip and Antiblock Formulations

Primary method for reducing blocking is the incorporation of slip or antiblock formulations in the resin by the polyethylene resin supplier. U.S.I., for example, tailors such additive formulations to various applications and extrusion conditions. These additives are designed to exude to the surface, or "bloom", after extrusion, imparting antiblock characteristics to the film or coating.

To understand how these formulations work, consider what happens when two polyethylene surfaces are in contact. (See Figure 1.) At room temperature, with no pressure on either film, the two films have relatively few areas of actual contact due to their microscopically rough surfaces. However, as temperature or pressure, or both, increase, plastic flow and elastic deformation occur. This increases the area of real contact, causing an increase in the two films' natural attraction for each other – i.e., blocking.

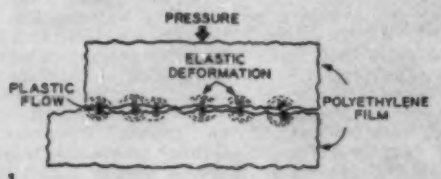

Figure 1.

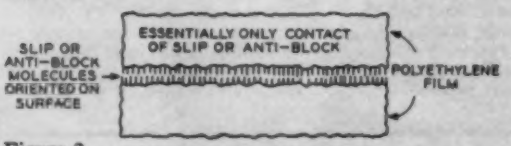

Figure 2.

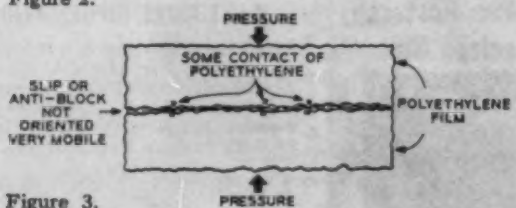

Figure 3.

However, films produced from resins containing slip or antiblock agents have a coating of non-blocking molecules oriented on their surfaces. (See Figure 2.) At room temperature, these molecules virtually eliminate contact between the polyethylene surfaces, giving the film the low blocking characteristics of the additive used. As temperature and pressure rise, the slip or antiblock molecules become very mobile and are no longer oriented, permitting some polyethylene-to-polyethylene contact. (See Figure 3.) Still the area of contact is kept to a minimum by the slip or antiblock agents, and unless relatively high temperature and pressure limits are reached, there should be no blocking problem.

Effect of Film Smoothness and Density

Other film characteristics affecting blocking are film smoothness and density. Very smooth, glossy films have a greater area of contact, and hence, greater blocking tendencies. Higher-density films have harder surfaces and are not so easily deformed. Consequently, they have less tendency to block, all other factors being equal.

Effect of Processing Variables

Processing conditions that produce higher film temperatures or greater pressure on films in contact, will increase blocking. Key processing variables in this respect are extrusion temperature, film cooling, windup tension and, in blown film, nip roll pressure.

Increasing extrusion temperatures may affect blocking two ways: 1. Produce higher film temperatures, and 2. Volatilize the slip or antiblock additives at the extrusion die. Either can cause blocking. Adequate cooling of the film is a countermeasure.

High-tension windup affects blocking by causing pressure on the film roll. The higher the film temperature at windup, naturally, the greater this effect.

Equally important – although applicable only to blown film – is the pressure on the film at the nip rolls. Since these rolls press the blown tube together at a point much closer to the die than the windup unit, they can influence internal blocking of the tube more than windup tension. However, if extrusion temperature is not excessive and cooling is sufficient, no problems should occur at the nip rolls when pressure is held near the minimum necessary to maintain a constant air volume in the "bubble".

Other Factors Affecting Blocking

Film gauge influences blocking too. Thin-gauge films are more susceptible to static electricity buildup and more difficult to separate due to their flimsiness. Any conditions favoring static buildup, of course, add to blocking. Also thinner films run at higher take-off speeds, with hotter windup and higher tension, increases the blocking tendency.

Unfavorable environmental conditions during extrusion or storage can also cause blocking. High room temperature warms the film, while stacking rolls or sheets of film or coated stock creates high pressure. Very low temperatures, on the other hand, may cause film shrinkage and resultant blocking.

When you have excessive blocking, first check your operation to see if modifying extrusion conditions can eliminate it. If blocking cannot be eliminated, consult your resin supplier. U.S.I. technical service engineers are available to help you find and eliminate problem areas.

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Division of National Distillers and Chemical Corp.
99 Park Ave., New York 16, N. Y.
Branches in principal cities

Letters

More on the Movable Screw Controversy

Dear Sir:

The September, 1961 issue contained a letter to the editor on page 950 accusing me of inaccuracies in an article entitled, "Movable Screw Plasticizing Boom." This same letter contained the following paragraph and I quote.

"The basic patent situation in single reciprocating screw injection machines in the United States is very clear. The only patent existant in this country is patent #2,734,266 issued February 14, 1956, filed by Mr. William Willert and assigned to Frank W. Egan Co. Any machine sold under its license has no confliction because there is no other known patent on the basic screw principle in the United States."

I am writing you because I am concerned about the fact that my own reply was severely edited by you with the result that the foregoing paragraph was allowed to stand unchallenged. The art of the movable screw is, in fact, much older than would be indicated by Mr. Fuller's statement. For example, there is patent #2,629,132 filed October 27, 1950 and issued February 24, 1953 covering the basic principle of the movable screw and assigned to the General Electric Company. In addition, there was a movable screw injection machine operating in Chicago in 1945 and in checking this down we find that this same machine is still in operation in Mexico. My purpose in writing you, therefore, is to emphasize the fact that the movable screw principle is an old one and yet it has only recently made its appearance on the commercial scene. Ankerwerk International are to be congratulated for their pioneering work in bringing the movable screw principle back to the molders' attention.

A. R. Morse, President
Injection Molders Supply Inc.

Dear Sir:

In your Newsletter (SPE Journal, August Issue), a new method for welding high density PE pipes is mentioned. May I call to your attention that this method has not only been practiced for years, but it has also been fully described in publications by E. Rottner, Kunststoffe *47*, 227 (1957) and *48*, 345 (1958) and patented for the Farbwerke Hoechst in Germany (DAS 1 055 154, 9.13.1956—4.16.1959).

Dr. G. Gruenwald, Locomotive & Car Equipment Dept.
General Electric Co.

A copy of Dr. Gruenwald's letter was sent to Phillips Chemical Co. with the resultant reply:

Dear Sir:

We refer to the copy of Dr. G. Gruenwald's letter of Sept. 8, 1961 to you concerning a news note appearing in SPE Journal, August issue, relating to a new method for welding high density polyethylene pipe.

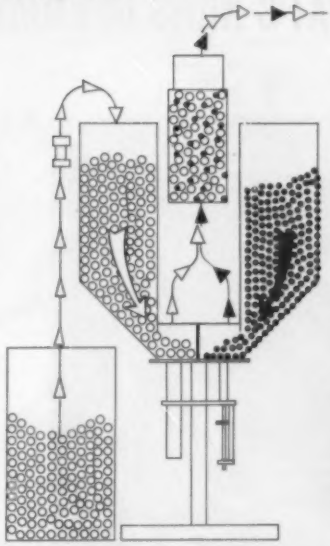
We agree with Dr. Gruenwald that the "method" is not new. Phillips has for several years been aware of publications concerning this type of welding method. To our knowledge, such publications go back to the year 1942, at which time the Dow Chemical Company published a pamphlet entitled, "Saran Pipe", disclosing a device in which a hollow plate was heated by a glass flame, which plate was then used to soften the ends of pipe sections and the softened ends were then moved together to form a weld.

As Phillips began to sell high density polyethylene into the market, a search was made for commercially available devices for welding plastic pipe. That search was not successful. For this reason, Phillips entered into a program for the development of a new "device" which could be easily moved about for field work. This program has been a success.

We greatly appreciate Dr. Gruenwald's calling this matter to your attention so that any misconception can be cleared up.

Dr. George Wash, Director, Plastics Sales Division of
Phillips Chemical Company

NOW Whitlock METERING CONVEYORS



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It means savings! Yes, it means savings when you automatically and accurately mix and convey cost-saving color concentrates with natural materials. And the Whitlock 600 Series Metering Conveyors have proven this in the field!

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Fine vinyl finish at 10-18% less cost

Here is another example of Enjay customer service. Enjay has solved an important surface coating solvent problem by experimenting with various blends of methyl ethyl ketone with methyl isobutyl ketone for vinyl surface coatings. With a 50/50 blend of these Enjay solvents—users can obtain excellent surface hardness, gloss, and finish at a saving in cost per pound of solids dissolved, relative to 100% MIBK, of 10-18%. This is one more example of how Enjay is helping its customers turn out quality products at a saving.

Enjay is a convenient source of basic chemical raw materials for most industrial and chemical needs. Enjay will supply tank cars of MEK, MIBK or will split tank cars for your convenience. Contact Enjay at 15 West 51st St., N.Y. 19, N.Y.

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RCI *Creative Chemistry . . . Your Partner in Progress*

"This POLYLITE *polyurethane foam* insulation is 5-ways better."

. . . W. L. Rothe, Pres., Leer Mfg. Co.

One model of the Leer ice merchandisers in which RCI POLYLITE foam insulation is now being used.

Leer switched to RCI POLYLITE polyurethane foam insulation after rigidly conducted tests by their own research department proved it gives their ice merchandisers these advantages:

- **Increased cubic capacity**—2-inch thick POLYLITE foam gives better insulation than 3½ inches of another material, permits thinner walls.
- **Weight reduction**—Less POLYLITE foam is used, yet it is more rigid, more adhesive, provides greater structural strength.
- **Floor Space Savings**—Units with substantially larger capacity now fit in the same space.
- **Durability**—POLYLITE foam insulation resists deterioration, is resistant to moisture and most solvents, retains a very low K-factor.
- **Easier installation**—Air-gun mixing and application of POLYLITE chemicals replaces manual operations.

Investigate the advantages of using POLYLITE foam resins in your applications. RCI supplies the complete "package"—including systems for densities from 1¼ to 30 lbs. per cubic foot. Write for details.

REICHHOLD

REICHHOLD CHEMICALS, INC., RCI BUILDING, WHITE PLAINS, N.Y.

SPE JOURNAL NEWSLETTER

reading time
1 minute

New Plastic Processing Patents

Some latest U.S. patents issued on plastics processing: Three for the forming and manufacturing of hollow plastic articles; one on continuous melt spinning of synthetic filaments; an extrusion die device for producing flat shaped articles; a grinding, mixing and feeding apparatus for plastic molding machines; mold carriers for use in rotational casting and a method for the manufacture of three dimensional objects by selectively heating plastic sheets possessing elastic memory.

Electron Microscopy for RP

Electron microscopy is now being applied to the study of the interface system in reinforced plastics, as a result of a new technique recently developed. Useful in studying polymer concentration on the various surfaces in the laminate, applications of this technique are discussed in the October issue of SPE TRANSACTIONS.

New Polypropylene Plant

A new 100 million pound per year plant was officially opened on September 21st, at New Castle, Delaware by Avisun (an equally owned affiliate of American Viscose Corp. and Sun Oil Co.) Formerly production was carried out at a 25 million capacity leased facility in Port Reading. Avisun plans biaxially oriented film in 1962.

Packaging Research

1200 scientists will be involved in packaging research and development at Continental Can Company's new research complex in Plainfield, Illinois. Some interesting plastics projects: High capacity blow molding units whose limiting factor is generally extrusion rate, injection molded polypropylene caps, Polyester-foil-vinyl cook in pouches, flex-on bags and ultrasonic sealing.

Satellite Blow Molding

Satellite plants for blow molding bottles are springing up all over the country. Some companies on the bandwagon: Owens-Illinois, Continental Can Co., Royal (owned by Celanese), Imco, Plax, and Bemis Brothers Bag Co. (through Air Formed Products Co.). Satellite plants are necessary because shipping costs on the plastics bottles become prohibitive for distances over 150 miles. Demand is so great however that some plants are shipping over 600 miles.

What's News in Plastics...

Escon® polypropylene brings you a balanced combination of properties for high-speed, low-cost molding. It has rigidity, surface hardness and strength yet plenty of resilience, so you can strip undercut parts from molds with almost no breakage or permanent distortion. **Escon** polypropylene performs well at maximum ram speeds and stock temperatures from 450-500°F (slightly higher for large items). Its dimensional stability practically ends post-mold shrinkage. And don't forget that polypropylene yields more parts per pound than any other commercial polyolefin molding material. For full details on how **Escon** can help you hold down costs while reaching new heights in performance, write to Enjay at 15 West 51st St., N.Y. 19, N.Y.

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY CHEMICAL COMPANY

A DIVISION OF HUMBLE OIL & REFINING COMPANY

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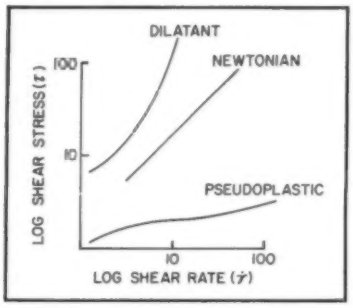
$$\eta = \frac{\tau}{\dot{\gamma}}$$

NEWTON AND THE NON-CONFORMIST FLUIDS

Newton's classical hypothesis, stated above, provides a basis for the study of viscous flow. However, many viscous fluids behave in a non-Newtonian manner. In polymer melts, for example, viscosity may vary with pressure and flow rate. These properties must be measured — with accuracy — in order that their behavior may be predicted in advance. Knowledge of flow behavior assists the researcher in studying molecular structure . . . helps the engineer in designing more efficient process equipment. Which is why we're using this space to tell you about the new Instron Capillary Rheometer, a valuable and versatile new tool for studying the behavior of polymer melts and other non-Newtonian fluids.



Newtonian fluids have constant viscosities with shear stress proportional to shear rate. Dilatant fluids show an increase in viscosity while pseudoplastics become more fluid at higher flow rates.

Designed for use in INSTRON Tester

The new Instron Capillary Rheometer (Type MCR) consists of an extrusion assembly mounted on an Instron Universal Tester. Temperature controls are contained in a separate cabinet. A sample of polymer or other non-Newtonian fluid is forced out through a capillary by a plunger driven by the moving crosshead of the INSTRON.

This basically uncomplicated arrangement makes possible a new level of convenience, accuracy, and versatility in the study of non-Newtonian fluids. For example:

Constant shear rate — The selected speed of the servo-controlled INSTRON crosshead is constant and independent of load; therefore, extrusion speeds and shear rates are constant. *Wide range of speeds* — The plunger is driven at speeds covering the range of 1000:1 in precise steps. *Permanent record* — Plunger force at each speed is detected by a load cell and plotted on the recorder. The force curve often indicates special flow properties such as critical shear rate. *Interchangeable capillaries* — For studying the effects of entrance, exit and transient losses. *High precision heat control* — a wide range of temperatures controlled to ±0.5°C.

Capillary Rheometer Mounted On Floor Model Instron

If you are interested in flow properties, write for our technical reprints on this subject. Also available: our ever-growing library of articles on advanced testing techniques, covering many fields — just mention your particular field of interest.

When accuracy is paramount it is the INSTRON that is often chosen to provide the standards — proof you can do more with an INSTRON. If you have any problem at all related to stress-strain testing, on any kind of material, write for the INSTRON Catalog.

For advanced instrumentation in stress-strain behavior- look to

The INSTRON comes in various models and sizes to suit the widest applications for use under all test conditions. Shown: Floor Model — load ranges from 2 grams to 10,000 lbs. Sales and service offices the world over . . . staffed with Instron-trained engineers.

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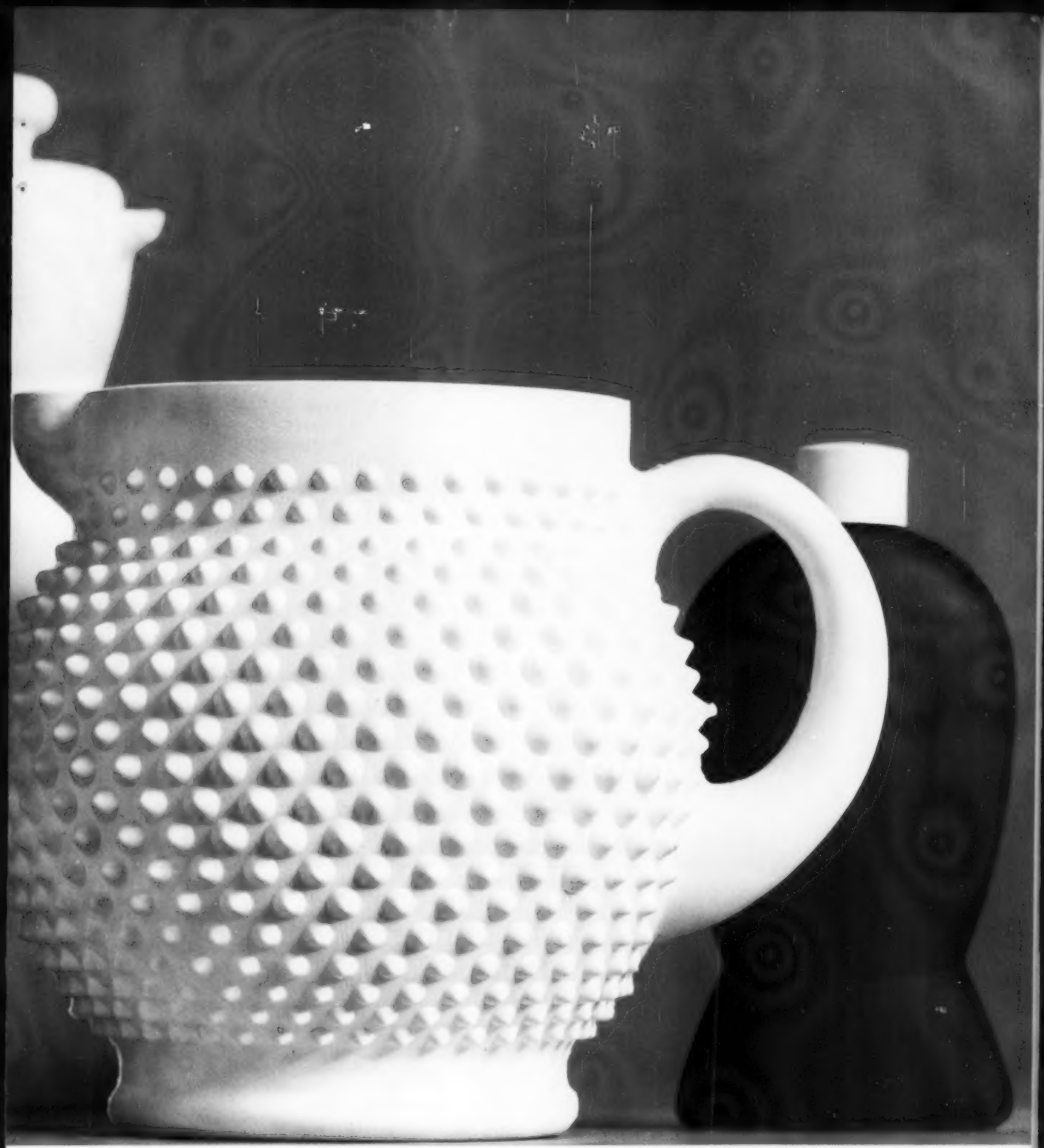
AMERIPOL® is a unique material even among high-density polyethylenes. It has exceptional impact strength and rigidity. In resistance to environmental stress cracking and thermal embrittlement, it outlasts comparable materials several times in accelerated tests. It withstands a wide number of inorganic and organic chemical environments. ■ Yet this strong, tough material is easy to process on conventional equipment, and is particularly adaptable for blow molding many shapes of bottles, containers, and similar products. AMERIPOL's outstanding chemical resistance makes it ideal for blow-molded containers for household chemicals. ■ A new technical bulletin lists pertinent data for blow-molded bottles. Write today for your copy — and request consultation with a Goodrich-Gulf Technical Service man. In materials and in service, Goodrich-Gulf is ready to help you improve container quality and cut costs.



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Can you run the new compounds on your existing equipment? What about pipe, profiles, other shapes? What extrusion screw design gives optimum quality and output on rigid PVC?

Tough questions? Yes — but not too tough for the Davis-Standard laboratory. Here you find the exact information you need to answer your extrusion questions. Skilled engineers and technicians actually set up and test run sample jobs on the most highly instrumented, production-sized extruder available anywhere. Fact is, many leading resin producers come to Mystic to test the extrudability of their new compounds.

This brief review of some of the precision instruments and equipment we have designed especially for experimental analyses may suggest the uncommon scope of information obtainable:

- Four extruder cylinder pressure transducers
- One die or head pressure transducer
- Eight extruder cylinder temperature sensing and control points with recording from either shallow or deep thermocouple positions in each zone
- Drive motor load recording
- Marker signal, indicating each full rotation of the screw for screw RPM recording

These inputs are then recorded continuously on Sanborn electronic equipment for analysis by Davis-Standard research people.

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Regional Technical Conference

Cleveland Conference to Feature Screw Injection Molding

December 1, 1961

Sheraton-Cleveland Hotel, Cleveland, Ohio

Screw injection molding, an unusually popular innovation in the United States during the past year, will be the subject of an SPE Regional Technical Conference in Cleveland on December first. Technical program of the Conference, sponsored by the Cleveland Section at the Sheraton-Cleveland Hotel, will be international in scope featuring speakers from West Germany, Switzerland, Great Britain and the United States.

A technique widely utilized abroad, screw injection molding has recently become of particular interest to the U. S. plastics industry. The complete technical program of eight papers will encompass all aspects of this molding technique including views and experiences of European molding machine manufacturers, a discussion of problems encountered by the molder and benefits of twin screw preplasticizing as well as views of U. S. equipment manufacturers and molders.

Luncheon speaker will be James R. Lampman, SPE Vice-President, Engineering, and SPE President-Elect, who will present a summary of Society action in 1961 and a view of the future of SPE.

The technical program announced by RETEC and Program Chairman Edward J. Haskins of Injection Molders Supply Co. follows:

8:00 a.m. —*Registration*

Morning Session

8:45 a.m. —**Welcome to Screw Injection Molding RETEC**
Henry E. Dutot, President, Cleveland Section (American Cyanamid Co.)
and
Edward J. Haskins, RETEC Chairman (Injection Molders Supply Co.)

Moderator: Milan Krajcik
Rubbermaid, Inc.

9:00 a.m. —William H. Willert
F. W. Egan Co.

9:45 a.m. —**Views, Opinions & Experiences of a European Injection Molding Machine Manufacturer**
Walter O. Seitz
Netstal Machine Factory & Foundry Ltd.

10:25 a.m. —John W. Mighton
Dow Chemical Co.

11:05 a.m. —Dr. Herbert H. Frimberger
Ankerwerk International

12:15 p.m. —*Luncheon*

Moderator: Jack R. Pecktal
Eastman Chemical Products

Speaker: James R. Lampman
1961 SPE Vice-President, Engineering and SPE President-Elect
(General Electric Co.)

Conference registration fees, which include luncheon and a copy of the RETEC preprint book, are as follows:

	SPE Members	Non SPE Members
Advance Registration	$11.00	$13.00
On-site Registration	13.00	15.00

Requests for further information and advance registrations should be directed to:

Charles A. Borton
RETEC Registration Chairman
c/o Hercules Powder Co.
55 Public Square
Cleveland 13, Ohio

Chairmen of other major Committees responsible for planning and producing the RETEC are: Publicity, James R. Jones, James Sales Co.; Printing, Samuel H. Smith, Jr., The Van Dorn Iron Works Co.; House, Donald R. Newman, Pyramid Products Co.; Secretary, Bernard J. Wulf, Injection Molders Supply Co., Inc.; Treasurer, Donald A. Draudt, Drecco Inc.

Afternoon Session

Moderator: David J. Sloane
Lester Engineering

2:30 p.m. —**Fundamental Problems in Screw Preplasticizer Injection**
E. Gaspar & M. B. Munns
Peco Machinery Ltd.

3:10 p.m. —**Panacea or Merely Another Tool**
Robert E. Partridge & Louis H. Barnett
Loma Industries

3:50 p.m. —**Benefits of Twin Screw Preplasticizers**
K. Baigent
Windsor, Ltd.

4:30 p.m. —**Plastics Parts Produced with Screw Plasticizing**
Samuel H. Greenwood
F. J. Stokes Machine Co.

The Buffalo Section was the host to an extremely successful Regional Technical Conference (RETEC) on Plastics Foams attended by over 500 people. Sessions were divided into two groups, Rigid and Flexible. The abstracts appearing below present the highlights of the meetings' discussions. The subject matter of the luncheon speech delivered by Dr. Raymond Ewell, Vice Chancellor of the University of Buffalo, was U.S.A. vs. U.S.S.R.—Strengths and Weaknesses. Dr. Ewell clearly indicated the tremendous economic strides that the Soviet Union has made in the past and great potential that they have for the future. He emphasized that definite steps should be taken to curb this strong menacing giant which he thinks is the prime adversary of the United States of America.

Plastics Foams Progress

**Highlights of the Regional Technical Conference (RETEC) "Plastics Foams"
Sponsored by the Buffalo Section, Buffalo, N.Y., Oct. 5, 1961
Advances in formulations, fabrication methods
and applications of cellular plastics materials.**

Process Modifications

Sigmund Orchan of the Coated Abrasives Division of the Carborundum Company outlined various new methods of preparing foams. In the vacuum type approach a carefully controlled formulation without any actual blowing agents is used where the prepolymer and catalyst mix are placed in a pre-heated vacuum oven. Upon evacuation, the foam expands and gelates. Next step involves a cure in a regular oven. The foam so produced has high tensile strength, tear resistance, rebound flexibility and compression set. The foam structure is more coarse and less uniform than those obtained by conventional means however. With certain refinements this method can be used where the high strength properties are desirable, and where this more cumbersome fabrication method is worthwhile. Carborundum's intended use is for grinding wheels.

According to Richard C. Bailin of Tronomatic Corp., steam molding of polystyrene has decided limitations such as lack of close density control, introduction of moisture, long production cycle, and a high mold investment. All this is in addition to the necessity of installing a steam distribution system. Some of these problems can be mitigated by the radio frequency expansion of treated polystyrene beads (workable to densities of 1.5 pcf.). Because of mold design problems applications are limited to small parts. However, investment and operating costs can be lowered in certain in-plant processing operations.

Properties

Work at the Lincoln Laboratory by E. B. Murphy and W. A. O'Neil has resulted in the application of infrared spectroscopy and dielectric analysis on urethane foam particularly as structural material for radomes. The visible region is used for examination of macroscopic and microscopic structure, the infrared region for polymer structure and the microwave region for dielectric properties. This is an interesting non-destructive method for the analysis of foams.

Dynamic and static physical properties of expanded rigid and semi-rigid polystyrene foam used in the development of polystyrene foam cushion design were compared by Charles Kienzle of Koppers Co. Test methods were outlined for the data which were presented graphically.

Formulation and properties of sorbitol polyether based urethane (rigid) foams are listed in a paper by S. Cear, G. Greth and J. Wilson of Atlas Chemicals. It was shown that the hydroxyl number can be correlated to the physical properties of the foam, as a higher hydroxyl number is associated with higher cross-linking density. A high hydroxyl number polyether is more costly, however.

Blowing Agents

A mechanism for efficient production of fine cells is proposed for polymeric extrusion where maximum efficiency is obtained when decomposition of the blowing agent approaches completion within the extruder and when decomposition continues in the extrudate until expansion is completed. Time-temperature characteristics are important here, claims Ralph H. Hansen of Bell Telephone Laboratories.

Henry R. Lasman of National Polychemicals in describing the physical and chemical methods of foaming polyolefins indicated that the chemical method does not have some of the advantages of the former. Physical means are inexpensive, odorless, non-toxic with no residue. The chemical method is adaptable, however, to processes using conventional rubber and plastics equipment. Chemical blowing technique was discussed for extrusion, compression molding and expansion of cross-linked polyethylene.

Polyethylene Survey and Urethane Construction Applications

Progress in polyethylene foam was the subject of a comprehensive survey by H. W. Tenney, Jr. of The Dow Chemical Co. The survey dealt with polyethylene foam production methods, properties and applications for both low and high density material. Low density type, which has high resiliency, low thermal conductivity low porosity and solvent resistance is used for thermal insulation, gasketing and bouyancy items. High density foam is mostly used in electrical insulation.

Urethane in foam stressed skin panels is used as a means for selling steel claimed M. Glickman of American Bridge. He outlined the problems involved in fabrication material selection, testing and market development where properties of adhesion, fire retardancy, load bearing capacity, wear resistance, dimensional stability, thermal insulation and density are important. Applications in building, automotive and office furniture fields were evaluated.

Newer Foams

News of properties and processing characteristics involving foamable epoxies and silicones was heard in Buffalo from H. Vincent and R. Moore of Dow Corning Corp. and R. Burge, A. Landua and R. Toohy of Shell Chemical Co. Epoxies although new, have found most of their applications for industrial sprays for low temperature insulation where such properties as chemical resistance are needed. Silicone foams which are highly resistant to temperature extremes, moisture and oxidation can now be prepared at room temperatures with relatively low densitites.

Cellular Vinyl Technology

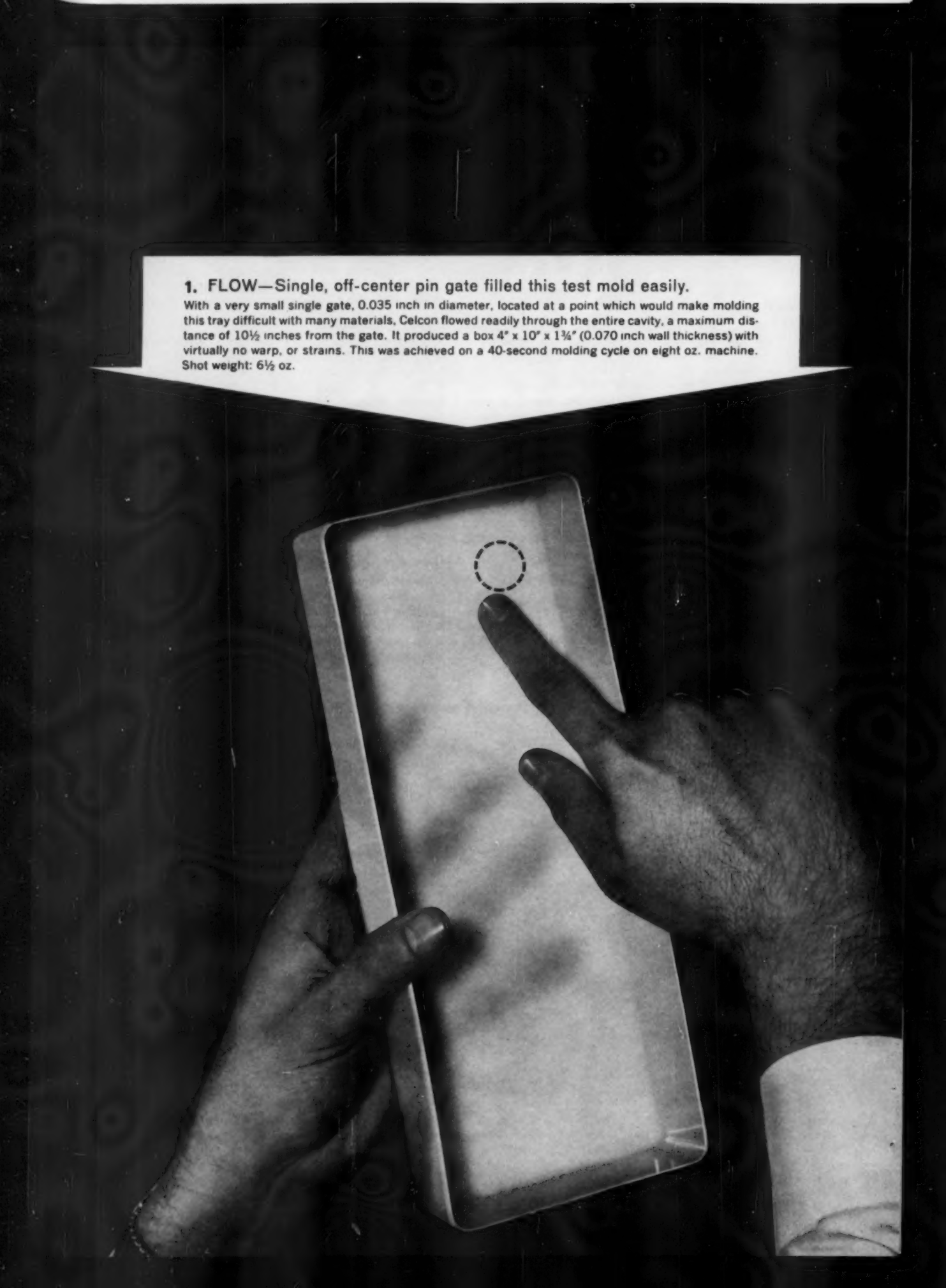
Blowing agents, formulations production techniques and application of vinyl foams were discussed in three papers by J. Meyer of B. F. Goodrich, A. Werner of Naugatuck and J. H. Hook and J. J. Krajcir of E. I. du Pont de Nemours. Meyer uses the extrusion process as a guide post for presenting applications in the other processing areas of injection molding, plastisol rotocasting and calendering and coating while Werner and Hook and Krajcir concern themselves with plastisol rotocasting as applied to "synthetic leather" applications.

Foam Regional Technical Conference (RETEC) Chairmen

Left to Right: Anthony V. Nasca, Lucidol Division, Wallace & Tiernan, Inc.—Master of Ceremonies; William Dunmeyer, Carborundum Corp., General Chairman; John C. Henderson, Atlas Plastics, Inc., President Buffalo Section SPE; Andrew J. Hammerl, Durez Plastic Div., Hooker Chemical Co., Registration Chairman; John P. Valentine, Durez Plastics Div., Hooker Chemical Co., Vice President; John R. Grenier, Protective Closures Co., Honorary Chairman; Matthew V. Perry, Lucidol Division, Wallace & Tiernan, Inc., Publicity Chairman, Printing Chairman, Co-Program Chairman.

1. FLOW—Single, off-center pin gate filled this test mold easily.

With a very small single gate, 0.035 inch in diameter, located at a point which would make molding this tray difficult with many materials, Celcon flowed readily through the entire cavity, a maximum distance of 10½ inches from the gate. It produced a box 4" x 10" x 1¾" (0.070 inch wall thickness) with virtually no warp, or strains. This was achieved on a 40-second molding cycle on eight oz. machine. Shot weight: 6½ oz.



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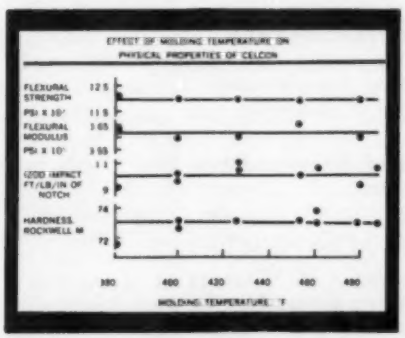
The new Celanese acetal copolymer, Celcon, is the *exception* among engineering plastics, traditionally difficult to mold. No longer is a sacrifice in molding ease demanded in order to attain other desirable properties. Celcon's radically new and different molecular composition assures ease of molding, while supplying the characteristics which make it a replacement for many metals and other plastics.

It has over 100°F. molding temperature range, during which essentially no polymer degradation occurs. Celcon flows easily and evenly; lends itself to fast cycle molding.

Moldability is only part of the good news about Celcon. There's more, including high-strength, resistance to chemical attack, unusual durability over long periods of time and conditions of use. The coupon will bring you complete details promptly.

2. BROAD MOLDING RANGE—Over 100°F.



Celcon has a broad molding range—over 100°F., during which the stability of the polymer is essentially unaffected. It molds well from 360° to 480°F., although material temperatures of 380° to 420°F. are suggested as usually best from the standpoints of cycling and optimum part properties and appearance.

3. REMOLDING—Celcon regrounds show little change from virgin material.

Comparison of ASTM properties of virgin Celcon with regrounds put through the molding operation five times indicates no significant change in properties. Celcon can be molded and remolded a number of times—thus allowing reuse of scrap on a normal basis.

EFFECT OF REMOLDING ON PROPERTIES CELCON COPOLYMER

		1st MOLDING	5th MOLDING
TENSILE PROPERTIES			
YIELD STRENGTH	PSI	9800	9400
ELONGATION AT YIELD	%	12	12
TENSILE MODULUS	PSI X 10⁵	3.75	3.70
BREAK STRENGTH	PSI	8000	7800
ELONGATION AT BREAK	%	60	60
FLEXURAL STRENGTH, 5%	PSI	13000	12000
FLEXURAL MODULUS	PSI X 10⁵	3.65	3.65
IZOD IMPACT STRENGTH NOTCHED	FT LB/IN		
73°F, 50% RH		1.1	1.1
-40°F		1.0	1.0
UNNOTCHED— 73°F, 50% RH	FT LB/IN	30	30
VICAT SOFTENING POINT	C	160	160

POLYMER COMPANY

A Division of Celanese Corporation of America
Canadian Affiliate: Canadian Chemical Company Limited, Montreal, Toronto, Vancouver
Export Sales: Amcel Co., Inc., and Pan Amcel Co., Inc., 522 Fifth Avenue, N. Y. 36

Celanese®

CELANESE POLYMER COMPANY
Dept. PC-129-K, 744 Broad Street, Newark 2, N. J.

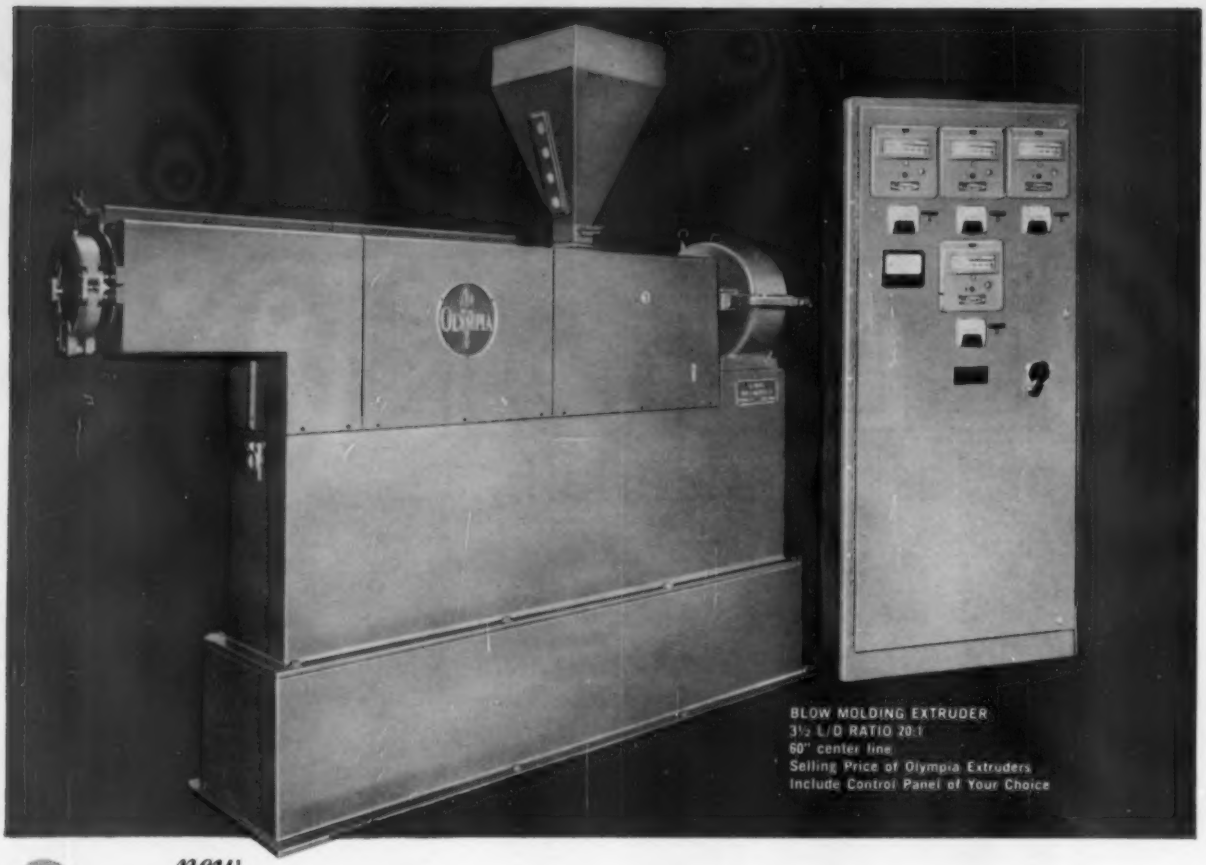
Please send me technical data on injection molding of Celcon.

Name_____

Company_____

Address_____

City_____ Zone_____ State_____


BLOW MOLDING EXTRUDER
3½ L/D RATIO 20:1
60" center line
Selling Price of Olympia Extruders
Include Control Panel of Your Choice

new

OLYMPIA PLASTIC EXTRUDERS

Are backed by 20 years of designing and building experience. Olympia extruders provide...

LONGER EXTRUDING LIFE

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NOTE: ***All wiring on the Olympia Extruder is completed at factory.***

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BLUEPRINT FOR BLOW MOLDING

Establishing the Successful Plastics Processing Plant

Richard S. DeBell*

Melvyn A. Kohudic
Editor

In recognition of the growth of plastics processing, and in particular blow molding, the SPE Journal has launched this pioneering effort to document the most important guideposts, technical and economical, involved in the successful entry to the business of the conversion of plastics raw materials. It is a general article—yet it is very specific. The first part may be considered a business primer. In it, sound engineering and business principles, general in nature, are reviewed in outline. Then later in the article, these principles are applied to the establishment of a plant in one of the fastest growing areas of plastics processing—blow molding. As an added bonus for the reader, the most vital information has been distilled to the form of a check-list; and certain important areas are reduced to typical bibliographical references.

A successful plastics processing business depends on the simultaneous exercise of a variety of skills. Failures often result from insufficient aptitude for—or interest in—only one of the several facets. The enthusiastic, sales-oriented executive may completely lose sight of the uninteresting factor that, for example, his product is technically not workable or his finances are inadequate to buy material, and the converse relationships hold for the engineer and/or financier.

Any enterprise is organized to make and sell a product at a profit. For ultimate benefit to the producer, his workers, his customers and the community, the enterprise should be a continuing one. The enterprise, must, to those ends: be well-organized; be adequately financed; have a marketable, useful product; have a sound production plan, facilities and labor; have a workable distribution system; and provide for a variety of other considerations directed at optimization.

Some Management Considerations

Organization—is the first step in solidifying a group of appropriate size and specialized abilities, establishing the extent of their operational authority and responsibility and, not incidentally, complying with regulations governing the establishment of a business.

In plastics it is singularly true that the key man in the organization may be the production foreman. It is often vital to have the assistance of a capable, intelligent individual who "understands" his machines, who can reason out the response of materials to processing variables, and who "talks the language" of his operators. While the entrepreneur is sometimes versatile enough to handle these functions, he should be free to administer to other needs of an organization of even modest size, confident the production will proceed smoothly in his absence.

Financing—capital may come from independent sources such as the assets of a present business, or from the commercial "money market" (2). Regardless, it is necessary to establish with some precision the extent of capitalization, since either over- or undercapitalization is attended by

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* Mr. DeBell is associated with DeBell and Richardson, Inc.

very real and sometimes disastrous disadvantages. Financing by whatever means provides the capital with which to establish, equip, start up and maintain production. Each of the areas must be considered in some detail to arrive at a realistic over-all capitalization of the required precision.

In the fever of buying buildings and equipment, and hiring operators, it is too often true that an entrepreneur fails to make adequate provisions for working capital. The need quickly and distressingly becomes apparent when a high-volume production operation swings into action. Taking as a rule-of-thumb that working capital should equal *at least* two weeks' raw materials plus two months' production, simple calculation may show working capital substantially equal to fixed assets, with high-production plastics equipment. Neglect of operating funds has been the downfall of many otherwise well-planned, well-equipped and technically sound businesses. Recent history provides evidence that blow molders are subject to these economic facts of life.

The financing area involves also the continuing control of the assets acquired during capitalization. The management of "the books" is perhaps a chore, and a grasp of the approximate distribution of capital in the business may seem so innate as to tempt the entrepreneur to take shortcuts. It is basic to the life of a business to have firm control of costs, to be aware of the status of all receivables and to limit the extent of borrowings, and these and other necessary financial sub-objectives can only be met with "tight" accounting procedures. Other cautions occasionally bypassed are to maintain a measured pace of expansion, assimilating each growth phase thoroughly, and to keep salaries and emoluments within reason.

The Product—Often Too Many Factors Neglected

Plastics use is stimulated by their several advantages, including light weight, color possibilities, corrosion resistance, unique mechanical and electrical properties and (sometimes) processability. Plastics materials may have disadvantages, too, and one would be remiss in failing to verify serviceability of his product under sunlight, aging, chemical exposure and/or continuous stress, especially where interruption of service (by the product) would react upon the manufacturer.

It is hardly possible to generalize on the requirements imposed on plastics, so varied are the applications, except to note that plastics material selection is both a vital consideration in the success of a product and an area in which assistance is easily obtained. Materials manufacturers are unstinting and knowledgeable in providing background information on specific material types and methods of fabrication. Professional societies, such as the SPE, SPI, ASTM and a host of others have done and are doing a great service in advancing plastics to the status of well-documented engineering materials. Machinery manufacturers, consulting firms and subcontractors may all provide valuable insights into the selection and proper use of plastics in specific applications.

Many materials and processes hold great appeal to the entrepreneur in that fabrication of attractive products in huge volume apparently is done effortlessly; herein lies one of the greatest hazards of plastics. The more attractive the process, the more quickly does competition extract the "gravy".

The manufacturer-to-be must seriously consider the state of the market for his product. Even the "get-rich-quick" artist can lose if he fails to gauge properly the time remaining to him in the rapidly-changing scene. Questions: Is the process in its infancy, consolidation or maturity? Is there a preferred (captive or specialized) market? Is there patent protection or a "trade-secret" advantage, and, if so, how secure is it? Are there the means to take full advantage of any time "jump" on the competition? Are there savings in labor, materials, or other available to me and not to others (for any of a variety of reasons)? How soon will volume producers be in the field, and how does an operation of the proposed size propose to meet or circumvent this entry? Am I being carried away by my enthusiasm for a product of my own design?

Plastics, like any materials, must develop into a product through the classical stages of design, "breadboard" (prototype), test, redesign (if necessary) and production design. These are respectively tests of feasibility, operability, serviceability, optimization and produce-ability.

In an art (or science) as young as plastics, production equipment often is developed concurrently with the product. In certain of the newer areas—blow-molding and bead-foaming, especially, each new machine, whether built by a machinery manufacturer or an enterprising converter, may well represent a contribution to the technology. In longer-established fields, procedures may have become somewhat more standardized, but production equipment and fixtures are still individual problems for each product. Injection-mold and extrusion-die design, for example, are sciences in themselves and not to be undertaken lightly. The least expensive single-cavity molds commonly start at $1000, exclusive of their engineering, and an involved family mold might not unreasonably be quoted at the price of a small molding machine. Molds are sensitive to the materials "shot" into them, and sprue and runner dimensions are tailored according to the resin used. Even well-engineered molds are subject to revision to account for material peculiarities.

The character of a plastics product may depend to a large extent on the way in which the material is handled. Styrene sheet, for example, may be glassy-brittle or tough depending on its "orientation" or mechanically-ordered molecular alignment under precise temperature control. Orientation may have negative effects, too, on the craze-resistance or dimensional stability of a molded or formed part. Improper handling of plastics may have a multitude of other effects without analogy in more familiar materials. Thermal degradation may embrittle an otherwise tough material, and can be avoided by judicious control of forming conditions or to some degree by proper use of chemical antioxidants. Certain materials are moisture-sensitive, and care must be taken to dry the resins to avoid making void-filled scrap parts. Localized shrinkage in cooling from forming temperatures may warp or otherwise deform the parts as the relatively large thermal contraction of plastics follows its normal course, and smaller-scale deformations may result in surface roughness.

In short, entry into a plastics product line through blow molding or any other processing procedure, requires either a detailed knowledge of the processes and materials, competent advice, or a good reliable subcontractor.

Production

The plant and procedures must be realistically planned to arrive at an optimum balance of cost and serviceability, and a delicate sense of proportion must be maintained in equipping a plant to suit its goals. The following paragraphs will review some of the necessary considerations.

Site—The plant should be as close as reasonably possible to the market, in general. The finished products are usually both bulkier and more subject to damage than the plastics raw materials. Other considerations—a widespread market, a requirement for regionally concentrated labor of specific skills (or at particular wages), tax advantages, or personal preference—may be overriding in specific cases and to various degrees. The precise plant location within a general area is influenced by proximity to transport or a major customer, availability of existing structures or expansion-room, and zoning regulations.

In some instances, product bulk is the central factor in site selection and dictates geographical dispersal of small branch facilities. In blow-molding or bead-foaming, the

check-list for ESTABLISHING a PLASTICS PROCESSING PLANT

This SPE Journal check-list shows, at a glance, the myriad details involved in establishing a business for the conversion of plastics raw materials. On one side of the check-list, the precepts are general and apply equally in establishing a blow molding plant or any other type of plastics processing plant. The reverse side gives information specific to blow molding—this because of the explosive activity in this field. The SPE Journal recognizes that a great number of its readers, in addition to being practicing engineers, are also practical businessmen. If this check-list illuminates even one stumbling block for the engineer-businessman of the plastics industry, we will have served you well.

FOR ANY PLANT
SEE INSIDE

THE BLOW MOLDING PLANT

A SPECIAL SITUATION

The Genera

Organization Form

- private ownership
- partnership
- corporate form

Organizational Duties

- duties must be defined
- responsiblity must be fixed
- should be personnel versed in each phase of the business

Financing

- independent sources such as assets of present business, private investors
- commercial money market, e.g. banks, syndicates, public offerings
- working capital should equal at least 2 weeks raw material
- allow for startup costs

Cautions in Financing

- accounting procedures should be tight
- receivables should be handled promptly
- avoid excessive borrowing
- expand at measured pace
- salaries in reason

Site and Buil

- plant site clos
  ing)
- any requireme
- tax advantage
- special require
- labor wage sc
- militant union

Plant Layout

- locate machine
- each work st
  space
- overhead conv

Product

- is it marketabl
- relate product
  for present l
- verify serviceal
- seek appropria
- insurance agai
  uct

ral Principles

uilding

close to markets (a must for blow mold-

rement for labor with specific skills?

tages

quirements of plant, e.g. food packaging?

e scale too high, labor too transient

nion?

ut

chines for smooth flow throughout

k station should have limited storage

conveyors preferable

table?

duct to present line, e.g. captive bottle
ent liquid product

iceability (aging, sunlight, etc.)

priate technical advice

against lawsuit arising from use of prod-

Process

- is it in its infancy, consolidation, or maturity?
- is there a captive or specialized market?
- patent or trade secret protection—how long?
- how soon volume producers?

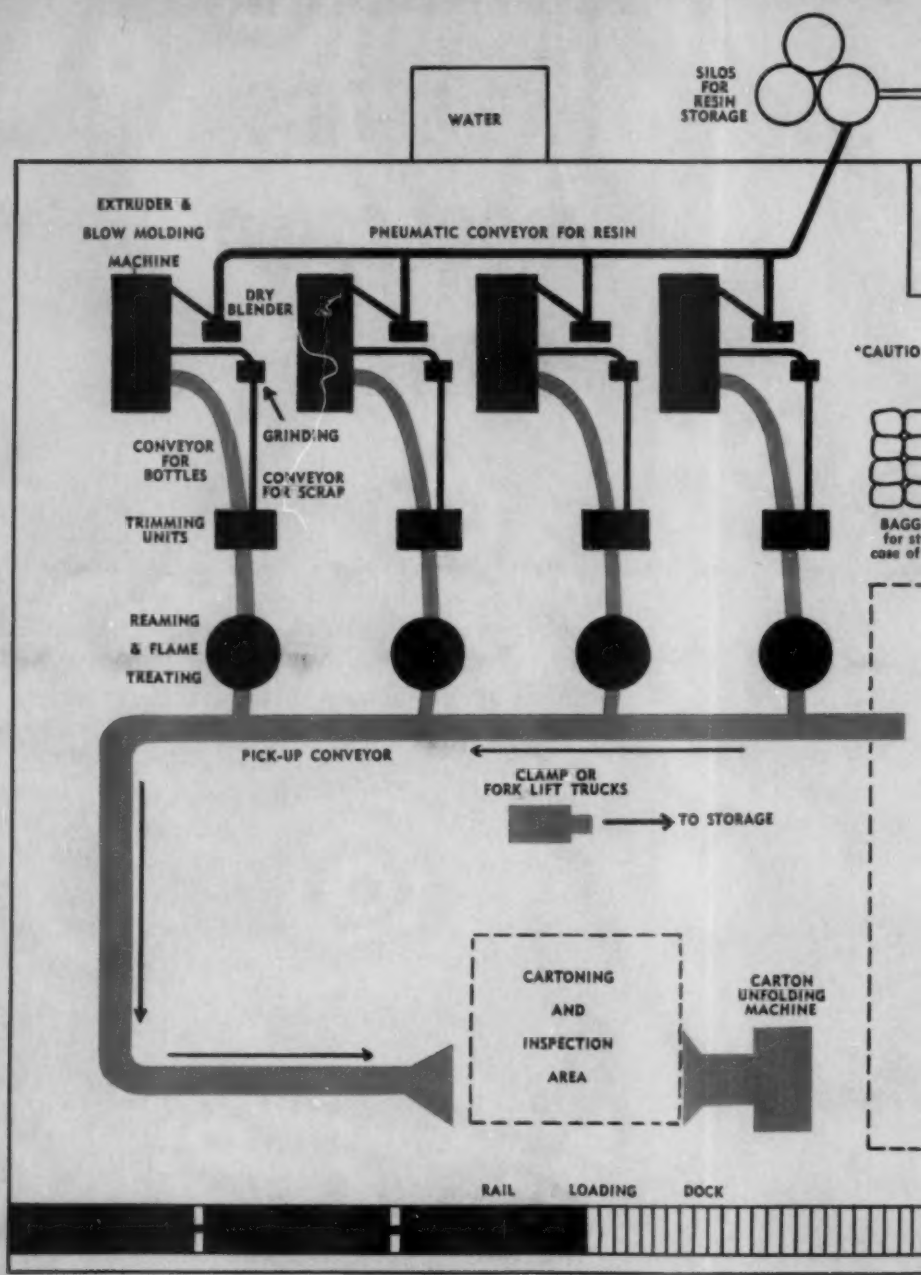
Machinery

- match primary machinery carefully to the specific job
- recognize need for auxiliary equipment
- capacities in line with expected production

Safety Considerations

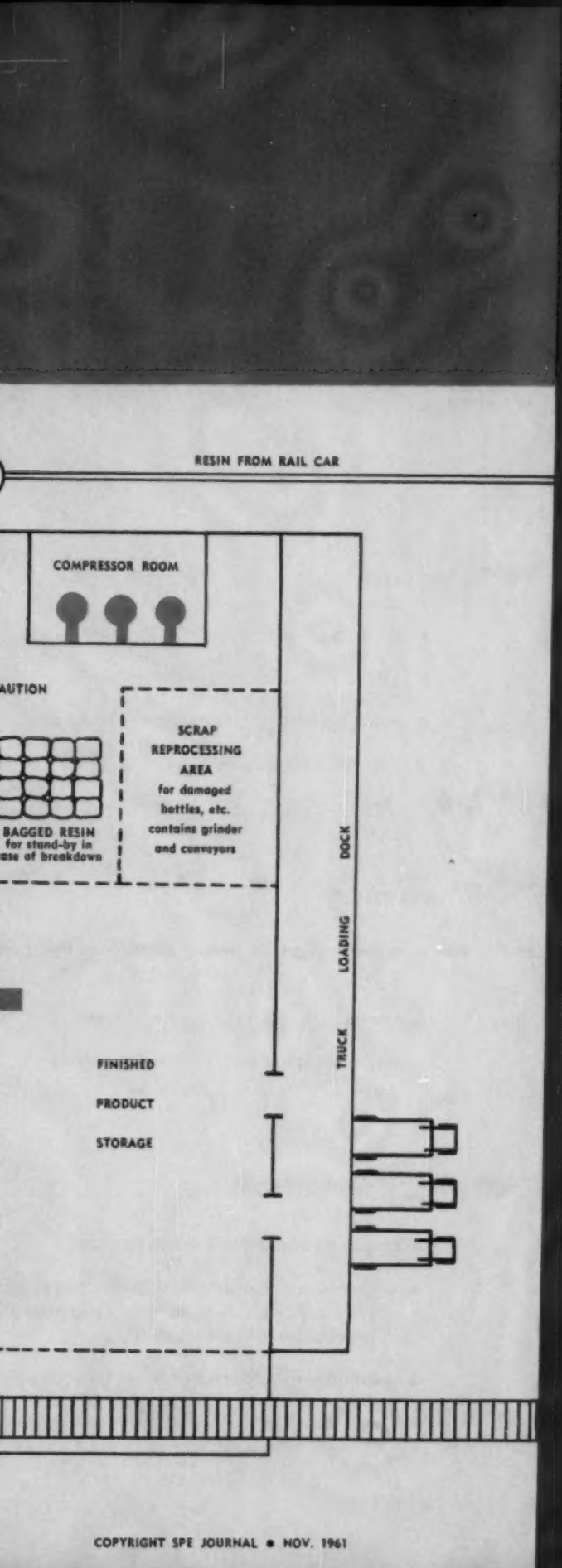
- guards on machines—insist on their use
- materials or fumes involved, refer to appropriate reference books, such as Sax's Dangerous Properties of Industrial Materials
- preventive maintenance program for equipment
- check state and Federal regulations, e.g. fire protection, exits, lighting, etc.

BLUEPRINT of a MODERN BLOW MOLDING PLANT



* Machine area must have good exhaust and daylight illumination

NOTE LOGICAL FLOW OF RAW MATERIALS, PRODUCT, STORAGE AND SHIPPING



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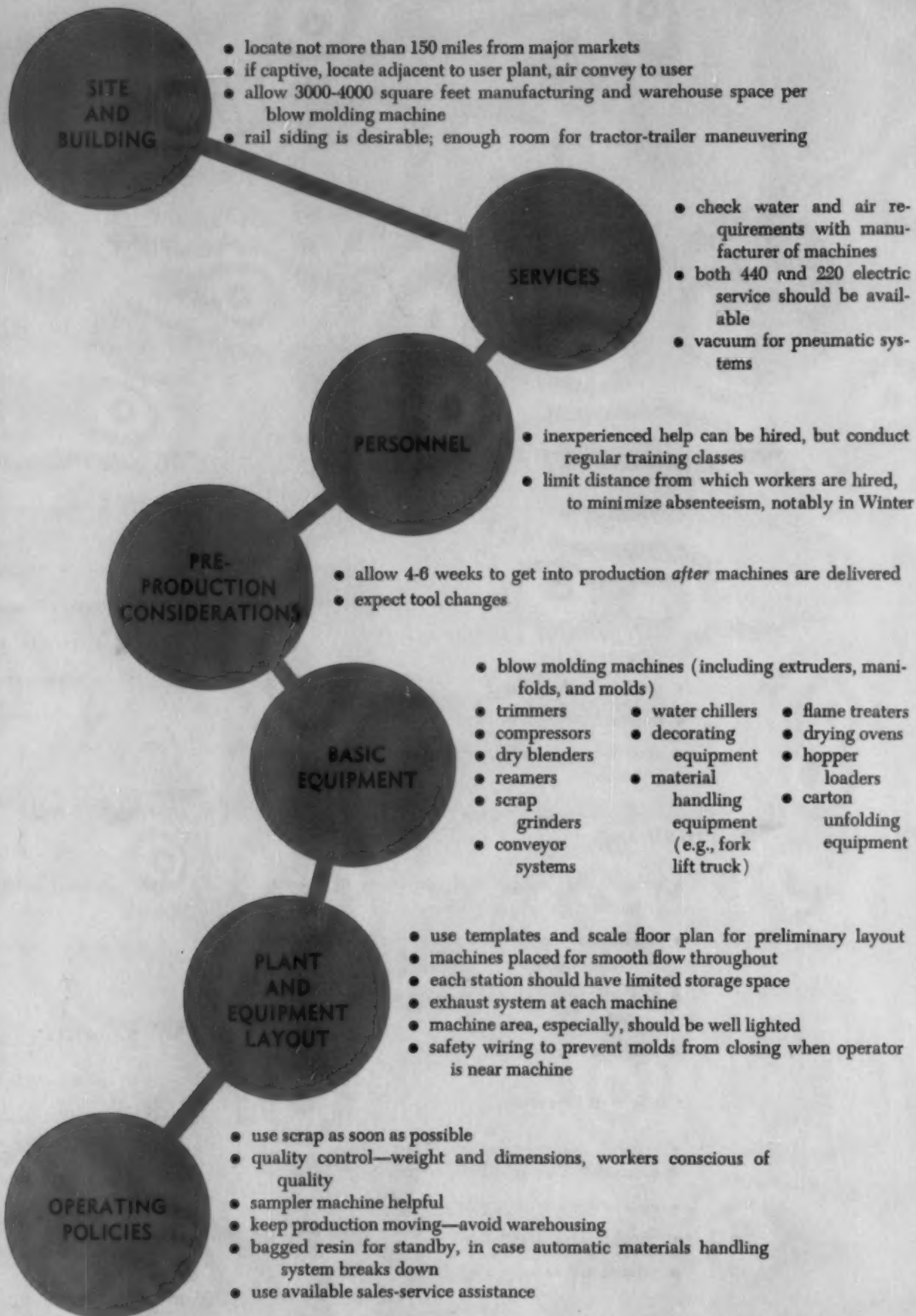
THE BLOW MOLDING PLANT

A SPECIAL SITUATION


SITE AND BUILDING
• locate not more than 150 miles from major markets
• if captive, locate adjacent to user plant, air convey to user
• allow 3000-4000 square feet manufacturing and warehouse space per blow molding machine
• rail siding is desirable; enough room for tractor-trailer maneuvering
SERVICES
• check water and air requirements with manufacturer of machines
• both 440 and 220 electric service should be available
• vacuum for pneumatic systems
PERSONNEL
• inexperienced help can be hired, but conduct regular training classes
• limit distance from which workers are hired, to minimize absenteeism, notably in Winter
PRE-PRODUCTION CONSIDERATIONS
• allow 4-6 weeks to get into production *after* machines are delivered
• expect tool changes
BASIC EQUIPMENT
• blow molding machines (including extruders, manifolds, and molds)
• trimmers
• compressors
• dry blenders
• reamers
• scrap grinders
• conveyor systems
• water chillers
• decorating equipment
• material handling equipment (e.g., fork lift truck)
• flame treaters
• drying ovens
• hopper loaders
• carton unfolding equipment
PLANT AND EQUIPMENT LAYOUT
• use templates and scale floor plan for preliminary layout
• machines placed for smooth flow throughout
• each station should have limited storage space
• exhaust system at each machine
• machine area, especially, should be well lighted
• safety wiring to prevent molds from closing when operator is near machine
OPERATING POLICIES
• use scrap as soon as possible
• quality control—weight and dimensions, workers conscious of quality
• sampler machine helpful
• keep production moving—avoid warehousing
• bagged resin for standby, in case automatic materials handling system breaks down
• use available sales-service assistance

transportation of the bulky product can constitute a substantial part of the purchase price of an article, and long hauls can be justified only by significant technological or economic advantages in centralization, as by completion of an assembly of cost large in relation to the foamed or blown component. Where a producer specializes to the point of supplying only blown bottles, for example, it may be logical to locate adjacent to a major customer, air-conveying the parts from his machines to this customer's. In extreme cases, an operation is sharply restricted by transport problems; a foaming operation making industrial packaging materials might not support distances greater than 50 miles by public conveyance or 150 miles by private truck, for example, and 150 miles is considered a limit for shipping blow-molded articles in the absence of special circumstances. At all events, where products are of low-cost material (as are many plastics) fabricated in low-cost, high-volume cycles, transport costs must be considered both in site selection and product selling price.

Building—Production exigencies may impose restrictions. Food-packaging operations, for example, may require special wall-surfacing materials and atmosphere regulation. Heavy production equipment will require sturdy underpinnings and their weight dictate ground-floor locations. Dimensional demands are made by long extrusion and takeoff trains or by tall presses or material-handling devices and access areas must be considered where bulky equipment is to be moved.

Type of construction must reflect both the meteorological and business climates. While certain high-unit-cost products may admit flossy facilities, the average plant might properly find more modest quarters in structures of modern functional-yet-economical design or in buildings adapted from decaying industries supplanted by plastics. Again, as in the garment industry, certain segments and types of plastics industry are unfortunately forced, by competition and/or by labor availability, into "loft" space of the meanest sort. Construction and rental costs are related by a 15-to-20 year amortization, and range from a rock-bottom of $.35/square foot/yr. to $1.50/square foot/yr. for space with heat and sprinklers; the range encompassing loft through laboratory. Building costs might be expected to range near $10 per square foot for manufacturing space, $16 for office and as high as $25 for laboratory facilities.

Services—Conversion of plastics materials may impose greater demands for services than do most other industries, and cost and availability of power and water may be significant factors in the planning of an enterprise. The resin must usually be heated through the melting point, at an expenditure of something like 100 BTU per pound of material, sometimes be transported at high viscosity through restricted passages at corresponding expenditure of energy, and be cooled rapidly to extract the heating energy plus any frictional-heat increment. In European practice, the cost of power and limited availability of water strongly influences the processing techniques, and is a powerful incentive in the adoption of screw-injection machinery in particular; these restrictions may even color the extent to which plastics are adopted.

The need may be present for other services; compressed air, steam, and/or vacuum lines are such auxiliary requirements and appropriate equipment-cost provisions must be made. Such "auxiliary services" may figure heavily in pneumatic conveyors, bag-molding or blow-molding operations, or bead-foaming or calendering operations, as examples, though some types of equipment are commonly made with self-contained compressors or vacuum pumps.

Machinery—Plastics machinery must be carefully matched to the specific job expected of it. While the general concepts behind any class of process are easily generalized, machinery is often aimed at very specific objectives. Injection machines for thin-wall containers may be utterly unsuited to shapes not in this general category, for example, and for such a reason the plastics entrepreneur cannot automatically expect satisfaction and must shop carefully for primary equipment.

Auxiliary equipment, too, is specialized in its applicability. More important in planning stages is to recognize the need and include funds for auxiliary equipment such as scrap-grinders, decorating and printing equipment conveyors, trimming devices, drying ovens, takeoff equipment and dry-coloring blenders or other mixers.

Auxiliaries must be selected according to the type of operation, though the precise types may not be as critical as in purchasing primary equipment. Capacities should be in line with the expected usage, in the case of blenders, ovens and grinders especially, since insufficient throughput here can be just as much a bottleneck as excessive downtime on the primary machines. Capacities are affected by the type of material fed; film scrap (requiring especially careful scrap-grinder purchasing) is bulkier than other types, yet at the same time is better adapted to air conveyance, as may be trim from certain vacuum-forming and blow-molding operations.

Labor—Labor markets of several types are available and should be considered in site selection and in relation to the proposed operation. Unskilled labor at low wages is available as a steady pool in a few specialized circumstances. Reprehensible as it may seem to exploit these sources, highly-competitive, low-overhead operations are (or claim to be) obliged to set up shop in big-city lofts to tap a supply of practically-transient labor. Such operations are often economically excluded from the Pittsburghs or Detroits, where high labor costs would destroy their ability to compete. It is (hopefully) more often than an enterprise should require the help of an untrained but alert citizenry such as is left in the wake of a displaced industry like textiles in New England. While such a labor pool might not have specific skills, it is able and eager to adapt to a new industry promising to preserve or improve a region's existence. Where a region is in the growth process, labor recruitment may require a still more advanced wage scale, regardless of the type of labor sought. Intricate or surpassingly technical work requires a still further salary increment, and may dictate location near educational centers such as New York, Boston or San Francisco.

Local labor situations may also deserve consideration, and the presence and militancy of unionism may figure in site selection, product pricing and production practices.

Plant Layout—Product design, with consideration of the manufacturing sequence, may be translated directly into a statement of the equipment required. It is important to locate the machines and/or departments in a logical layout designed for smooth flow of material through the plant, with or without orderly side-loops or tributary lines to integrate decorating or assembly operations not required on all products contemplated (see layout of a satellite blow molding plant on checklist). Each work station should have adequate space for temporary limited storage of materials or products when conveyors are not used. When a plant is conveyorized, these lines should be placed to avoid unnecessary interference with equipment movements (and especially, mold changes) and personnel traffic. Plant layout in any case, must be tailored to the operation, and is usually a composite of the most-applicable features of a variety of basic patterns of material flow or equipment arrangement.

Other production considerations—Plastics machinery can be as lethal as any other, and safety precautions must be observed. Guards are provided on most machines; they should be kept in working order and their use insisted upon. Where plastics are subjected to high temperatures and pressures, the gaseous decomposition products can introduce special hazards. A valuable reference in these cases is Sax's

Dangerous Properties of Industrial Materials which will identify unusual dangers such as the generation of phosgene by decomposing fluorocarbons.

Safety of equipment is also important, and proper maintenance precautions are recommended where decomposition products are acid and may pit machine surfaces, for example. Rust is a chronic problem with highly-polished molds, and may be avoided by judicious use of protective sprays. Hydraulic lines should be kept clean, and reservoirs at service level to avoid damage to pumps and valves. Maintenance data furnished by machinery manufacturers should be sought and adhered to.

Warehousing of materials or products should be avoided where possible, as an unnecessary expense and because it ties up otherwise active capital. Storage of molds and dies on the other hand, is a necessary function to which close attention may properly be given; some schools of thought feel mold "libraries" justify fireproof, climate-controlled vaults.

Auxiliary machine shop services are regularly required for equipment modifications, etc., and while elaborate facilities are not always required, a few basic tools and a designated area within the plant are properly contemplated. An acquaintance should be established with a reliable machine shop even where in-plant facilities are extensive.

State regulations, governing sanitary facilities, fire protection, exits, lighting, and related factors, should be investigated. While state and insurance inspectors will verify compliance, it is sometimes unnecessarily expensive to make minor revisions to a plant to satisfy these demands.

Market and Distribution

It has been implicitly assumed that a market awaits the product. **Caution**: The entrepreneur cannot make this assumption; rather he should assemble reliable data measuring his market as accurately as possible. He needs objective opinions other than his own, and an unbiased—even critical—appraisal may illuminate flaws he has neither suspected nor been warned of by "friends" unwilling to cause him concern or discouragement.

The distribution of the product may also pose problems. Even where a single customer is willing to undertake the distribution, the producer should guard against the possibility that his customer will use the dependence as a price lever, ultimately pricing the producer into oblivion. Effective distribution channels of several types are available, and the success or failure of a venture may hinge on a proper selection.

The Blow Molding Plant

— *A Special Situation* —

Up to this point, general principles have been described in this article. Now many of these principles will be applied specifically to the establishment of a blow molding plant. The editors of the SPE Journal have selected blow molding because there are more new plants going up in this area of plastics processing than in any other. There are now about 350 blow molding plants in this country. Small, custom blow molders are joining the ranks almost everyday. Intermediate size custom and captive operations are also springing up. And satellite plants are being constructed by such companies as Owens-Illinois Glass Co., Continental Can Co., Bemis Brothers Bag Co., Imco (Rexall), Celanese Plastics Co. (through Royal Manufacturing), Plax, T. C. Wheaton, and others. Countless other companies, such as Ball Brothers, Armstrong Cork Co., and Purex Co. are thinking of getting into the business, either as an extension of current manufacturing activities in the container field or as a captive operation.

First Things First

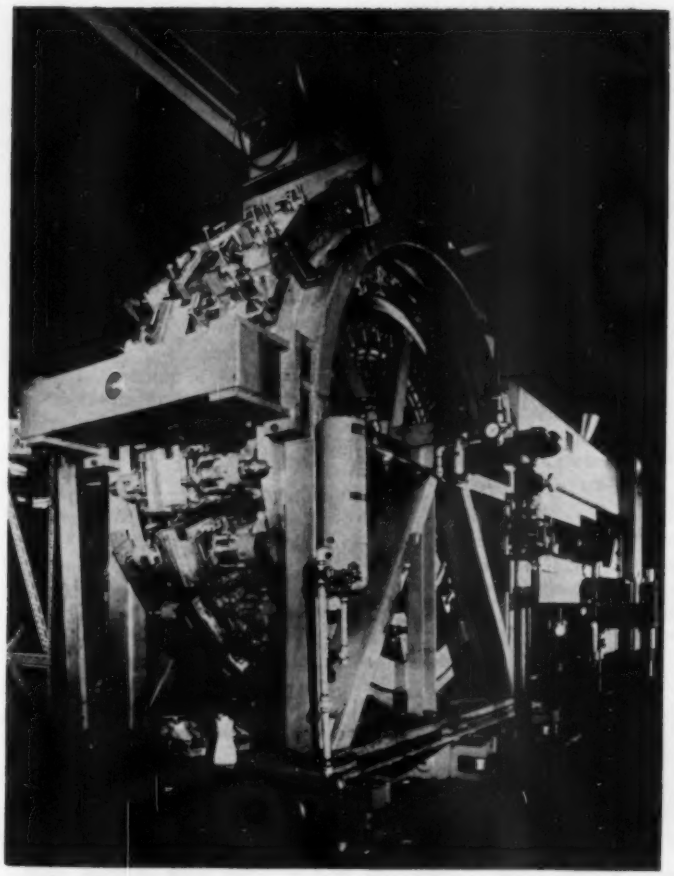
In any detailed plan, the basic considerations of organization and financing, referred to on pages 1159 and 1160, should be reviewed.

Also, the statement is made earlier that the plant should be as close as reasonably possible to the market. This is of paramount importance for a new blow molding plant. One rule of thumb developing is that shipping distance not exceed 150 miles. When one considers that shipping via tractor-trailer can cost between $20-$30/hour, the importance of distance can be appreciated.

One of the factors which makes a blow molding plant a special situation is the matter of space requirement. Because the blow molder is sometimes called upon to warehouse finished parts, such as bottles, a large storage area is necessary. Several blow molders, with some operating experience under their belts, have arrived at a figure of 4000 square feet of manufacturing and warehousing area required for each blow molding machine.

In the preliminary stage, it is a good idea to have a scale floor plan of the new plant, on which paper or cardboard templates can be placed to show positioning of machinery and secondary operations, and to show smoothest possible flow of raw materials and product through the plant.

Electrical, water, and air services should be laid out before machinery is installed. Enough 440 volt service should be available for extruders, motor drives, and other heavy equipment, while 220 should be available for the blow molding manifolds, exposed heater bands, etc. Water supply, along with chiller units, if necessary, must be adequate for the number of machines in operation. **Caution**: Check all service requirements with the machine manufacturer.



The blow molding machine of the (near) future. The machine pictured above was developed by Continental Can Co. It shows the familiar wheel shape that most of the new and modern machines are taking. The 25-cavity unit above operates at 100 bottles a minute, and could operate at 250 a minute if an extruder were available to provide sufficient quantity of resin. Continental Can Co. also has a new neck finishing machine that can handle bottles ranging from 12 to 32 ounces, and a flame curing unit, soon to be introduced.

While it may appear to be basic that a manufacturer have the equipment to manufacture with before he asks for an order, some blow molders contract to do certain work and *then* go after equipment. The result: A crash program, along with all the difficulties and disadvantages attendant with such a program. It is wise to keep in mind that tool changes will have to be made and machines adjusted. These pre-production delays can easily add up to 4 to 6 weeks.

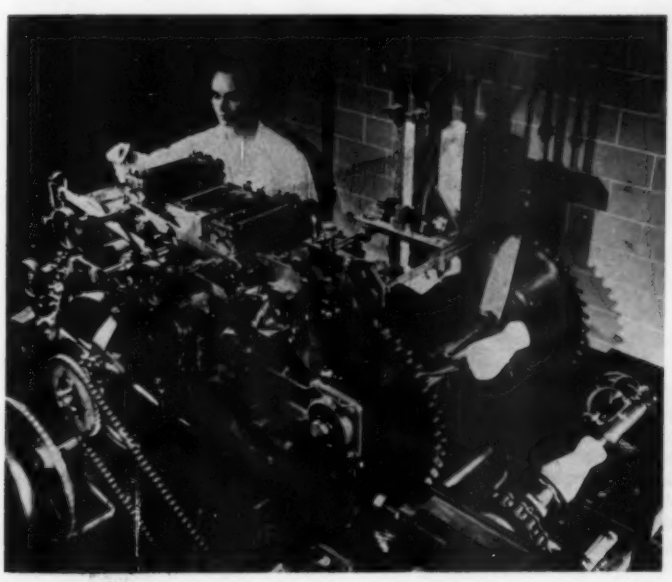
Details of Plant and Equipment Layout

The plant and manufacturing equipment should be laid out so that the flow of material through the plant is as logical and smooth as possible (see layout of satellite blow molding plant, on checklist). From the standpoint of industrial hygiene, grinding and reprocessing of scrap, unless done right at the machine as in large satellite plants, should be done as far from the manufacturing area as possible because of the high noise level. Each machine also should have adequate provisions for the collection of dust and other fumes.

Trimming units especially should have wire mesh or other guards as safety measures. The blow molding machines themselves must have safety features to prevent closing of the mold when an operator is in attendance. One blow molder has his machines wired so that the service platform beside the machine actuates a solenoid switch, making it impossible for the mold to close when an operator or maintenance worker is standing there.

Other equipment to be installed in most blow molding operations includes a reamer, flame treater equipment, hopper loader, granulator, dry blender, and possibly a bottle printing unit. In the most efficient operation, a suitable web conveyor system would connect all the elements. Not mentioned above but included in some installations is an oven in which the temperature is carefully controlled for annealing the bottles as they come from the molds. By such annealing, the finished dimensions of the bottles are held to closer tolerances, minimizing changes to the tools. Other equipment which might be needed: Drying ovens for such resins as nylon and acrylics.

Speaking of equipment, it is a good idea to have a sampler machine in the plant. With such a machine, production machines don't have to be shut down to make samples, quotes can be given quickly and with greater accuracy, and tools can be proved out before placing them in production. Suggested for this purpose is a single station, fast cycle type. A used machine could be adequate.



Various methods of printing and decorating blown plastic bottles are being investigated today. The picture above shows a prototype machine for offset printing irregularly-shaped plastic bottles, in four colors, and on both sides, developed by Continental Can Co. The machine prints one side then transfers the bottle to the other end of the unit where the second side is printed at speeds greatly in excess of current practice.

Operating the Plant

At several of the new blow molding plants visited by the SPE Journal, the comment was made that it was difficult to establish a blow molding plant because there were no experienced blow molding personnel available. This is true, particularly if the plant is small. However, the larger blow molders have found that they can call upon their suppliers—machinery, resins, instruments—

to come in and conduct training classes for the new and inexperienced plant personnel. In this way, and in a short time, qualified operating personnel will be available.

Quality control almost always involves checking the weight and wall thickness of the blown pieces. However, go: no go gauges are also convenient quality control tools. Production sampling every half hour from each machine is suggested as an adequate procedure. Some of the new, modern satellite plants being planned now will have automatic quality control (dimensions and weight). Bottles or other objects will pass over a weighing point in the conveyor system. If a defective unit is found, it will automatically be rejected. Electronic go: no go instruments will replace the manual gauges.

There is a considerable amount of scrap generated in any blow molding operation. It is a good policy to use the scrap that same shift or at least during the next shift. If it is allowed to accumulate, it may pick up moisture or become otherwise contaminated. Satellite plants very probably have the pinchoff trim going right back to a grinder beside the machine via a conveyor from the trimmer. Rejects and other scrap are ground up in a separate area, and conveyed to the dry blender at machine-side by pneumatic tube.

Some candid comments of blow molders

"You can't be a custom blow molder because even for one machine, too much space is needed."

"If you waited until you had enough capital to start, you'd never get started."

"I wish money was never invented."

Blow Molding Plant of the Future

Very likely, the production of the blow molding plant of the future will be geared to the production of the liquid being packaged. For instance, if bleach is the product, there will probably be a bottle filling machine in line with the blow molding machine. After all, this move is only an extension of the idea of building satellite plants. We are now going through the intermediate step of building satellite plants adjacent to the end user plants. The next step is logically shipping the bottles (or other articles) via pneumatic conveyor systems, though the idea did not work with tin cans. Considering the cost of packing empty bottles and then shipping them hundreds of miles, the prospects of bottle production geared to product production are tantalizing.

Another area of blow molding in which there will be many changes is decorating. Currently, most blow molders flame treat only. The several processes currently promising include application of labels by adhesives, silk screen process, transfer labeling (Therimage, trademark of Dennison Manufacturing Co.), and dry offset. The silk screen process is especially suitable for short runs. Automated equipment soon coming on the market, however, will make this process attractive for long runs. New fast-curing inks also will help to make it more attractive in the future. In the Therimage process, the label, gravure-applied earlier on a clear coating, is supplied on a paper carrier and applied to the bottle surface by a heated roller. The dry offset method should be considered if volume runs and multi colors are involved. Other developments, disclosed by Mr. William O. Bracken, Hercules Powder Co. (at an SPE-sponsored conference held in October in Louisville) include a new decorating technique called deep engraving and a recent technique developed by Alpine AG of Augsburg, Germany, which enables the blown part to be decorated in two or more colors while still in the mold.

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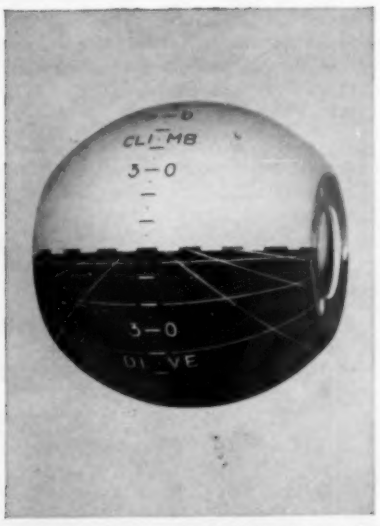
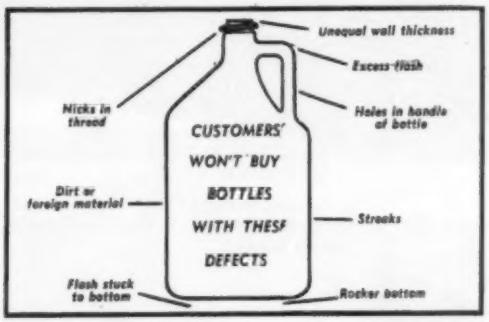
(Ungar Electric Tools)



DIMENSIONAL STABILITY. Maximum allowable change in this 5-inch aircraft instrument part is only 5 mils over a temperature range of —65° to 300°F! And it must maintain this tolerance under high humidity. Part is injection molded of LEXAN resin as half spheres which are solvent cemented, lathe-turned and painted. (Lear, Inc.)

HOW TO MAKE YOUR WHOLE PLANT QUALITY CONTROL CONSCIOUS

The answer in the heading to this box is simple: Tell the workers what defects to watch for. It is important how you tell them, though. For instance, tell them that "our customers won't buy bottles with these defects" (see drawing at bottom). In addition to having a color drawing of the finished product showing what defects to look for, a check list on what defects to look for at specific operations should be posted right at the site of that operation. For instance, at the trimmer a check list might be posted to tell the operator to look for nicks, excess flash, rocker bottom, and shallow threads.



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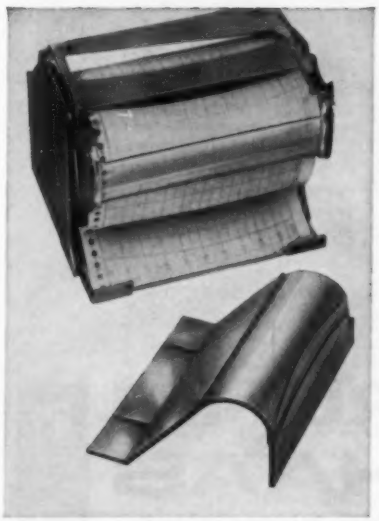

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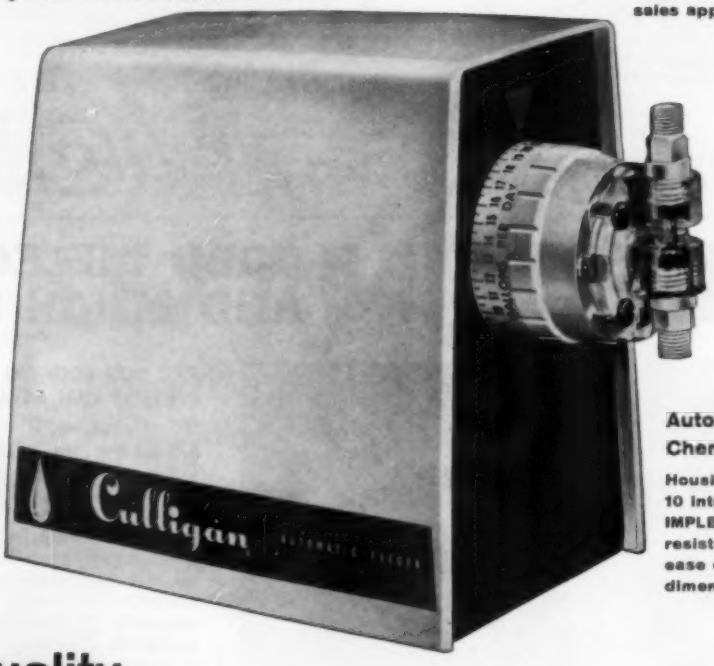

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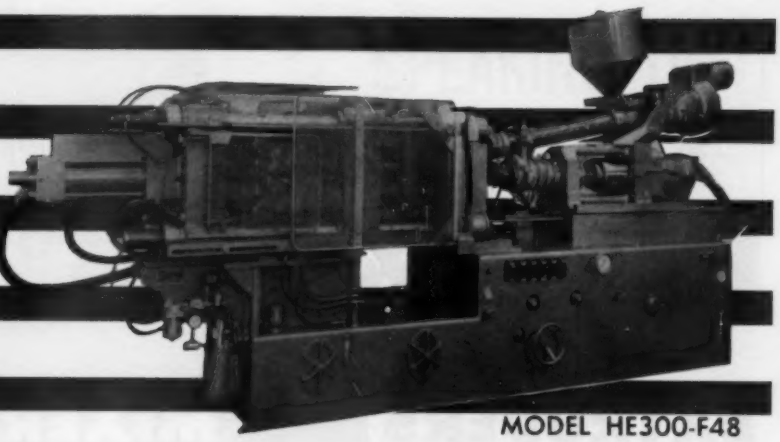

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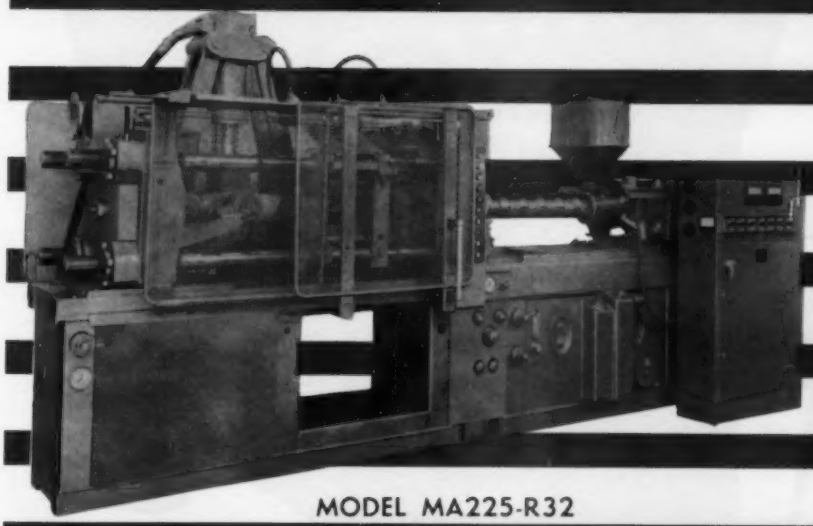

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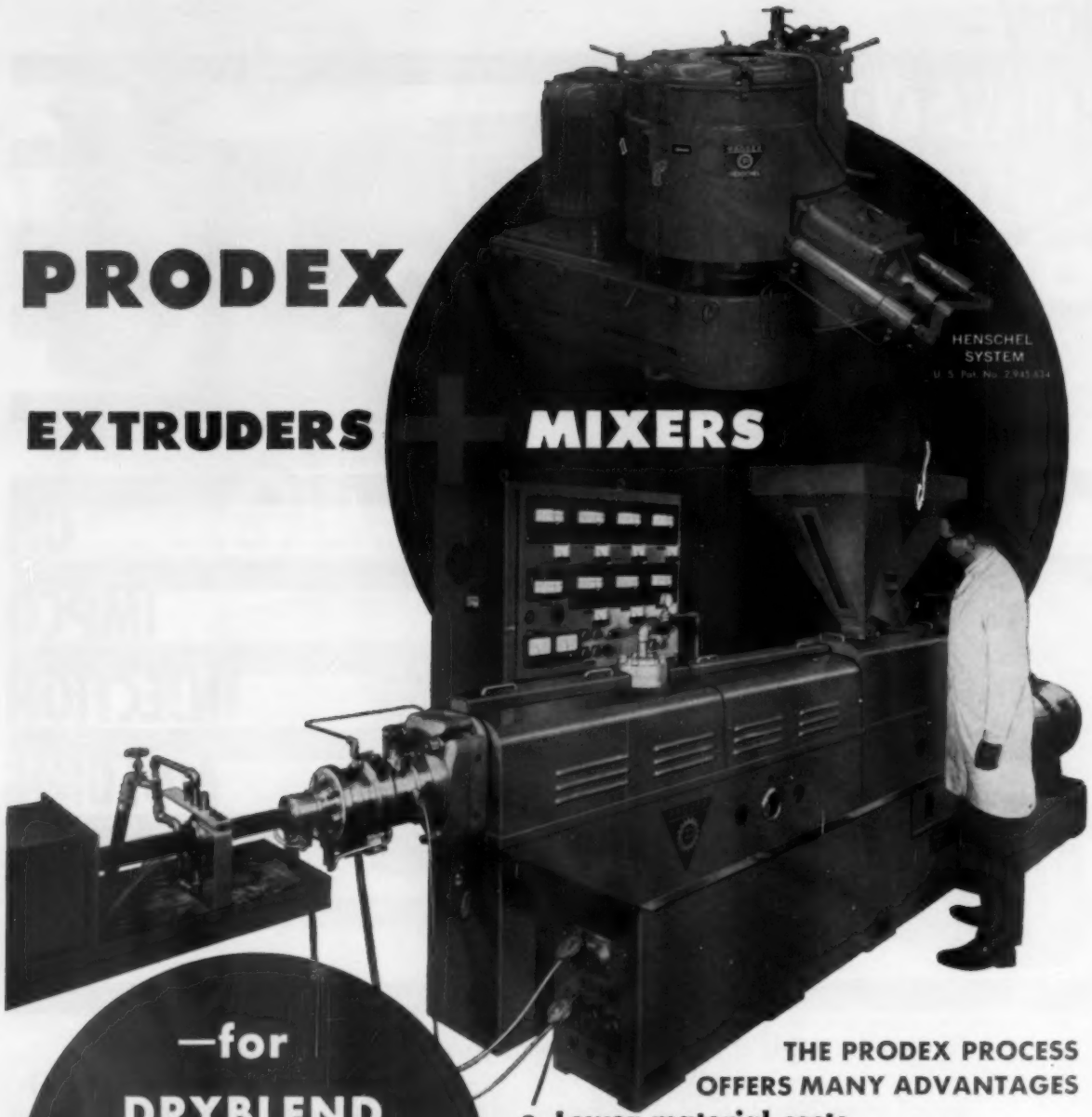

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SPEAKING OF EXTRUSION

Thickness Measurement of Extruded Film

A recent advance in the promotion of extrusion technology, and in the successful production of a high quality product at minimum cost, has been the use of nuclear energy for the continuous, non-contacting measurement and automatic control of extruded plastic sheet and film

The subject of nuclear radiation measurement is a rather broad field and encompasses many facets of both nuclear theory and process control. Ever since the Atomic Energy Commission released radioisotopes for industrial use, there has been an ever continuing development of devices which can and are used by industry for measurement and control purposes. In the plastics industry isotopes are used to measure fill level in tanks, boxes, hoppers, and other forms of containers. Other devices measure the density or specific gravity of liquids in chemical processing operations. The application of primary interest to those dealing with plastics sheet and film is the use of isotopes for the measurement of film thickness or weight on a laboratory or on a production extrusion process. Subjects to be covered include the basic principle of operation, how the equipment is used, and some of the reasons why equipment of this type has been so well received and accepted by the industry.

Device Principles

These devices are rather simple in concept though their application to a practical working system can be somewhat more involved. A radioactive isotope is nothing more than one of the basic elements of nature in an unstable form which generally emit beta particles to become stable. With few exceptions the isotopes used in radioisotope thickness gauges are the by-product or waste material obtained from a closely controlled atomic or nuclear reactor. Many of the thickness gauging systems in use today are known by the general name of beta-gauges, as they utilize released beta particles for their measurement. After a period of time the level of beta radiation produced by the isotope becomes too low to be useful as the isotope approaches a stable state, or a state where no further radiation is given off. Usually radioisotopes can be used in gauging equipment until the intensity of the emitted radiation is one-half of its original value, this period in time being called its half-life. As an example, Thalium 204 has a half-life of approximately four years. On the other hand, Strontium 90 has a half-life of about 28 years. Krypton 85 with a half-life of 10 years is commonly used in film applications.

One of the most important aspects of the isotopes choice is the nature of the material to be measured. Generally speaking, a low energy beta source such as Krypton 85 is utilized in the measurement of plastic films in the range of ¼ to 30 mils thickness whereas a higher energy source, such as Strontium 90, is utilized to measure plastic sheet in the range of 3 to 150 mils thickness. Sources are available for measurement of even heavier plastic sheet. The choice of the proper isotope, the amount of isotope to be used, and the method with which it is used are extremely important factors in the design of the source and detector components of the system.

The beta gauge system essentially consists of a radioisotope source to emit the beta particles or electrons, a detector to detect the radiation, and a means of presenting the detected radiation on some visual indicator, such as a meter or recorder. *(Figure 1)* Some of the radiation passes through the material being measured and a certain amount is stopped by the material. That radia-

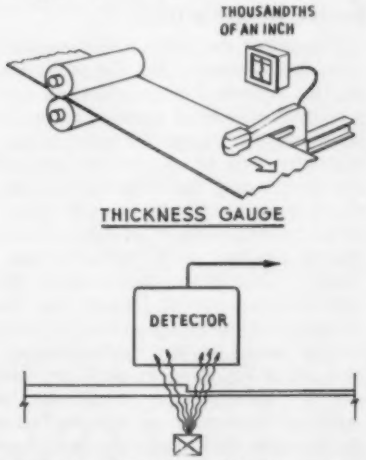

Figure 1. Principle of beta radiation transmission absorption

tion which passes through the material enters an ionization chamber or other form of radiation detector, an ionization chamber being primarily a sealed container having a very thin covering over the end facing the radioisotope source. This allows the beta radiation to easily enter the chamber. The chamber contains a gas, such as Argon or Krypton, so that the entering radiation will strike the gas molecules causing electrons to be driven off. A voltage difference is placed between the shell of the chamber and its insulated collecting probe thus producing an electric field. The free electrons move in the electric field allowing electrical current to flow in the circuit attached to the probe. The current produced will vary as the radiation entering the chamber varies, or as the thickness of the material varies. The remainder of the electrical circuit is then devoted to the measurement of the current flowing in the external circuit. Since it is quite difficult to directly measure current in the area of milli-micro amperes set up by the ionization chamber, one of the most commonly used methods is to introduce a very high resistance in the circuit in order that the small current flowing through the high resistance will produce a voltage of sufficient magnitude to be easily measured by a meter or a recorder. By weighing on an analytical balance or obtaining the accurate thickness of a series of samples of material and relating these measurements to the response of the system as indicated on the recorder, the measuring device can be calibrated to read in the units of measurement most commonly used for the material. This type of measuring device is commonly called a transmission type beta gauge and is the principle used in the large majority of plastics applications.

Source Detector Unit

To collect the various features and functions necessary for the operation of the system into a practical and workable system, a number of major units are necessary. As an example, a means must be devised to support the source and the detector over the sheet to be measured in such a way that nearly perfect alignment between the two units will be maintained. This unit, often called the source-detector unit, must also be designed to meet special application requirements of the particular process. A source-detector unit designed for a paper process would not be suitable for use on a steel mill due to the steel mill requirements of having an extremely rugged source detector unit to prevent damage to the unit when "wrecks" occur on the mill.

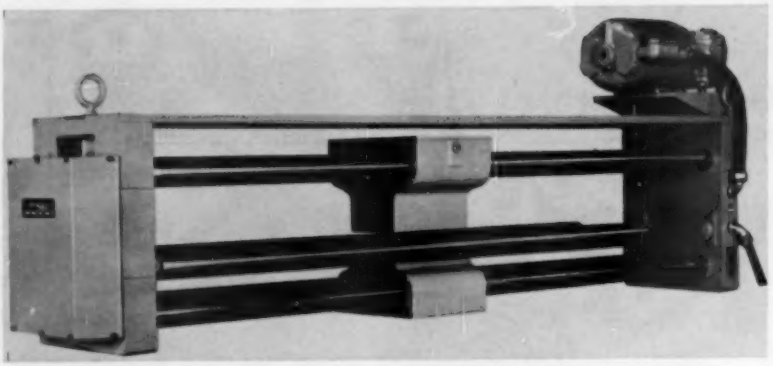

Figure 2. Traversing source—detector measuring unit

The miniature 0-frame source-detector unit, designed especially for use in the plastics industry, requires a minimum amount of process and aisle space. (*Figure 2*) This unit consists of four precision ground steel tubes supported at either end by cast aluminum end members. The source is located in the bottom cast aluminum housing and the detector in the upper housing. Both of these housings contain bronze sleeve type bearings which traverse on the steel tubes and are driven by means of chains and sprockets by an electric motor attached to one of the end members. The unit is designed such that the upper and lower housings maintain alignment within specified tolerances even though they are not rigidly connected together. Both the required process space for mounting and the aisle space for off-sheet standardization are kept to a minimum with this design making it ideally suited to the majority of plastic extrusion processes.

Electronic Packaging

In one production system design the electronic circuitry required to convert the detector signal into a usable reading is contained in a large equipment bay. In this system the equipment bay contains four swing-out type doors each of which contain several modular type panels with the necessary electronic components. Each module performs one function in the system and is designed for maximum reliability and serviceability. The cabinet may be remoted several hundred feet from the source detector unit and contains all functions for both the measurement and the traversing of the source and detector unit. Plug-in components, rugged industrial type relays, suitable part and component identification, an interior service light, and other service and reliability features are incorporated in this industrial design. Where the complete system incorporates automatic control for the process, the control functions are contained in a similar cabinet.

Automatic Controls

The complete measuring system consists primarily of three basic parts —the source-detector unit, the equipment cabinet, and the operator's station. A fourth part, automatic controls, are optional and, when used, determines the average weight or thickness of the sheet as obtained on a complete scan across the sheet. This value is then compared with the target or specification value. Should an error be found to exist, a corrective signal proportional to the amount of error is sent to motorized rheostats on either the screw or the take-away speed control units to bring the process back to target.

The controller incorporates a number of safety features to prevent erroneous control of the process and has a number of basic adjustments that are performed at the time of installation to allow the controller characteristics to be matched to the process. Many thickness measuring systems on film and sheet extruders utilize automatic control to aid the operator in maintaining the product within closer tolerance limits.

Flat Die Application

The use of non-contacting gauging systems on flat die sheet and film extruders is very straight forward. The source-detector unit is located either before or just after the rubber take-away rolls. Automatic control of machine direction variations is obtained through the automatic adjustment of either the screw or take-away section speeds. Die adjustments for profile control is performed by the operator by direct correlation with the recorder measurement presentation as the source and detector units scan across the sheet.

Tubular Film Applications

On tubular blown film processes the source-detector unit is located

after the film is brought together into its double lay flat form. (*Figure 3*) In this application the non-contacting system is actually measuring a double thickness of the film. While this presents no problems as far as machine direction control is concerned, interpretation of the chart for profile control purposes is not as easily accomplished as on flat die extruders. If the process utilizes air ring or die rotation the chart interpretation for profile adjustment is made somewhat easier. However, because the control and maintenance of good profile on this process is rather difficult, plus the fact that the operators become extremely proficient in the interpretation of the recorded information after gaining experience with the system, non-contacting systems have been very well received by those performing this type of extrusion.

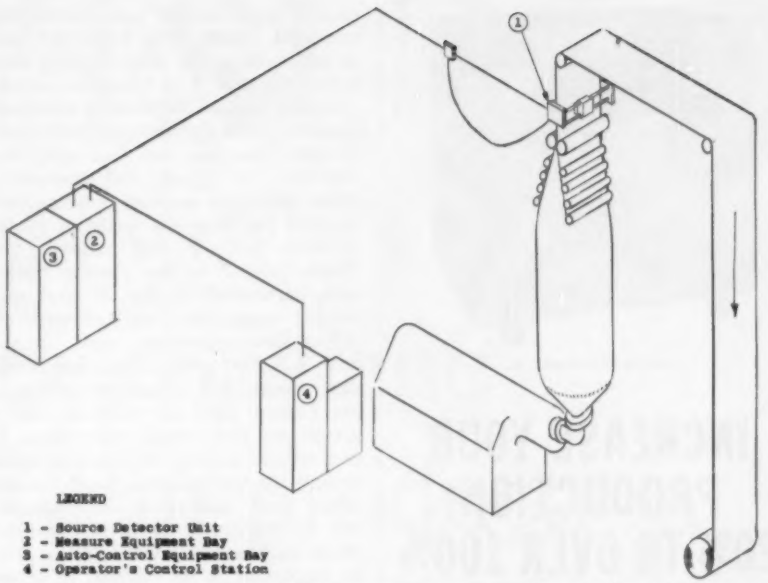

Figure 3. Tubular extruded film measurement and control system

Extrusion Coating Applications

On extrusion coating applications the direct measurement of the extruded film is not practiced due to the space limitations imposed by the process. Consequently two source-detector units are utilized, one measuring the base or substrate material and the second unit measuring the coated product. (*Figure 4*). The measuring system's response can be set up such that the two measurement recordings on a two-pen recorder will overlap when the correct amount of coating is being applied. In addition, a special purpose difference computer can be utilized to provide a recording of the absolute amount of coating being applied if certain process application requirements are met. Since scanning measurement is required by this application, both profile and machine direction information is presented and can easily be interpreted for control of the process.

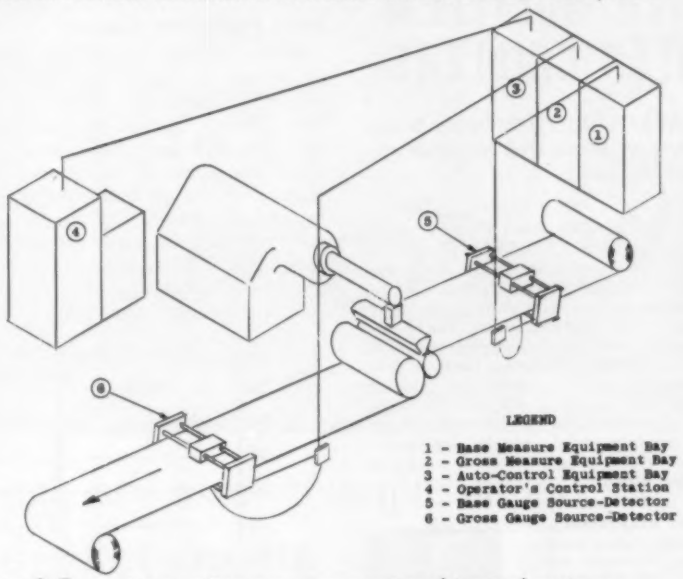
LEGEND
1 - Base Measure Equipment Bay
2 - Gross Measure Equipment Bay
3 - Auto-Control Equipment Bay
4 - Operator's Control Station
5 - Base Gauge Source-Detector
6 - Gross Gauge Source-Detector

Figure 4. Extrusion coating measurement and control system

System Economics

For satisfactory non-contacting thickness measurement it is necessary to eliminate or reduce as many variables as is economically and technically practical. To provide a meaningful measurement it is necessary to design additional functions, such as source and detector scanning, into the system. How much does a complete production type system such as this cost? Much depends on how much emphasis is placed on accuracy, reliability, and on meaningful measurement. As an example, a very accurate measurement will be next to useless if the system has poor reliability or if the system lacks the necessary functions to provide a meaningful measurement truly representative of the product variations. For these reasons, initial system costs can and do vary depending upon the functions and features incorporated in the system.

How can management justify such an expenditure for equipment of this type? The one single most obvious benefit is the ability of the user to improve the quality of his product by virtue of the fact that he is now able to continuously and accurately measure the material as it is being produced and to make process corrections to immediately reduce the variations in weight or thickness that the system detects. This is a significant and considerable improvement over periodic destructive sampling techniques previously employed. Improved uniformity, or increased quality, is an intangible and consequently it is very often difficult to assign a dollar value. However, there are instances where, for competitive reasons, the improved quality brought about by a radioisotope control system was enough to justify the cost of the system. For, generally speaking, the user of plastic film and sheet desires to purchase the product with the greatest uniformity. Often many factors in the converting of plastic sheet and film are closely related to the product's thickness. As an example, variations in film thickness can markedly alter the effectiveness of heat sealing equipment, it being stated dwell time, which is directly

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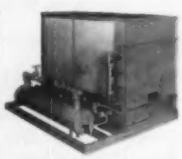

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related to production rate, should be increased about 50% for every mil of added thickness when sealing film in the range of 1 to 5 mils to obtain optimum seals. Thickness variations, both long and short term, profile and machine direction, can thus alter the efficiency of a heat seal operation. When extrusion coating polyethylene on kraft paper in the range of ½ to 2 mils, the per cent adhesion is closely related to the coating thickness, particularly in the ½ to 1 mil coating range. Heat seal strength of polyethylene extrusion-coated aluminum foil, as another example, can vary from 1950 grams of adhesion per coated inch of width to 2550 grams per inch when going from 1 to 2 mils of coating thickness at fixed sealing bar temperature. So it can be stated that uniformity in thickness can be important to both the producer and user in itself, and can also be important in its relation to other quality factors of the product.

More Pieces Per Pound

Some plastics are sold on a pound basis with a guaranteed yield, and others are sold on strictly an area basis. Where the end product is sold on an area or piece basis, it is a reasonable objective of the film producer to produce the greatest possible number of units per pound of raw material used and still meet the set tolerances for the material. Because a processor has been unable to control his product to close tolerances he has been forced to run his production with an average weight or thickness at or often above the set specification target to be assured his customer received no material lighter than required. Many times, too, the process is run heavier than it should be due simply to the feeling that "we would rather be heavy than light". An actual case showed that for a 0.9 mil order the process was actually producing a film having an average thickness of 0.9622 mils. (*Figure 5*) The thickness distribution curve indicated sigma limits, or a bandwidth of ±0.057 mils with conventional micrometer control methods. With continuous non-contacting measurement on the process, the product averaged 0.9174 mil with a bandwidth of ±0.047 mil, and with automatic screw speed control the product averaged 0.8995 mil with a bandwidth of ±0.033 mil. The reduction in bandwidth from ±0.057 to ±0.033 mil represented a significant improvement in product thickness uniformity, approximately a 42% reduction. The reduction in the products average thickness from 0.9622 mils to 0.8995 mils represents approximately a 6% savings in raw materials consumed in producing the same area of final product.

Most often savings of this type are taken in discreet increments in order that data can be accurately obtained relative to the degree of variation

(Continued on page 1190)

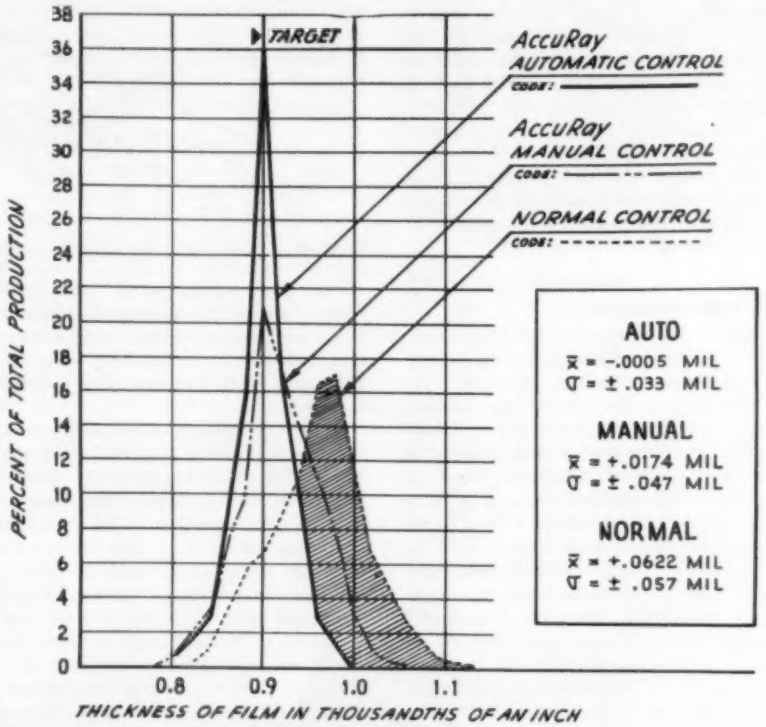
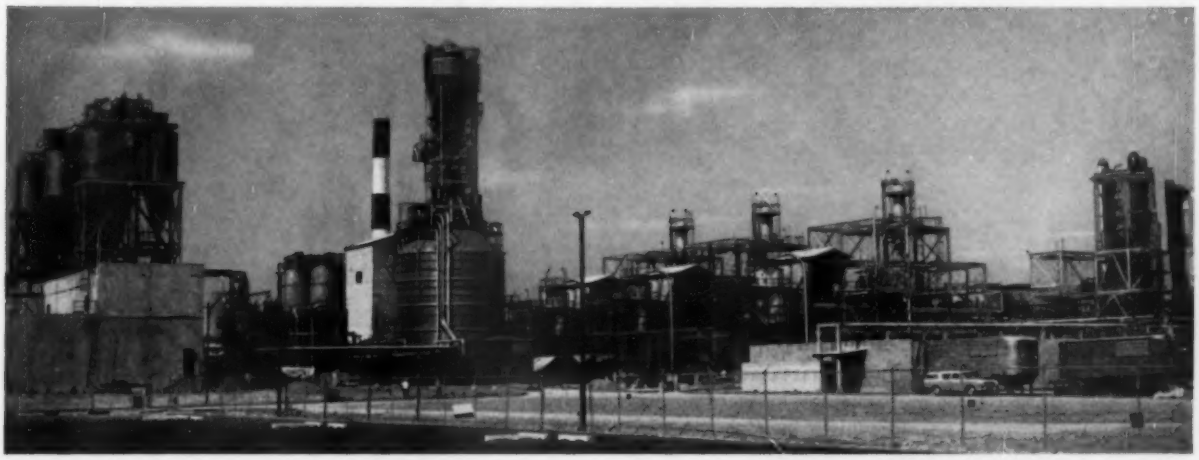


Figure 5. Extruded film thickness distribution

AVISUN

announces world's biggest polypropylene plant now in production



100 million lb/yr capacity assures ample supplies of polypropylene for the fast-growing number of users

This giant new plant at New Castle, Del., establishes AviSun more firmly than ever as the industry's leading polypropylene supplier. It incorporates the most advanced manufacturing techniques—continuous processing—meticulous quality control—to produce polypropylene polymers of top quality and dependable uniformity. The polymers include a broad new range of impact grades, pipe grades and other specialty resins for fiber—and wrapping film in varying mil thicknesses.

From this great new facility will come the materials for strong, light, low-cost products of every description to meet the needs of home and industry.

And AviSun stands ready with technical assistance. Fully equipped Customer Service laboratories—specialists with a broad and diversified background of experience in application problems—are at your service.

So plan now to explore the advantages of manufacturing or packaging with AviSun polypropylene. Complete technical data on AviSun polymer and film will be sent on request.

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Oleform is available in a blue-gray molding grade in *experimental* quantities. AviSun technical specialists stand ready to assist you in any developmental work. For full details, fill in and mail coupon today.

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COMPARISON

Properties	ASTM	OLEFORM	Acetal	Nylon 66	Wood Flour Filled Phenolic
Mechanical[a]					
Tensile Yield Strength[b], 10^3 psi	D638	4.5	9.8	8.5-9	7.5
Elongation at Yield[b], %	D638	6	10	60	1
Tensile Modulus[c], 10^5 psi	D638	2.9	3.75	1.75	10
Flexural Modulus[d], 10^5 psi	D790	5.5	4.1	1.75	10
Izod Impact Strength, ft-lb/in notch	D256	0.9	1.4	2.0	0.3
Physical					
Specific Gravity	D792	1.24	1.43	1.14	1.45
Heat Distortion Temp., °F	D648				
at 66 psi		295	338	360-390	300
at 264 psi		205	212	150-170	275
Water absorption (24 hr.) %	D570	0.02	0.12	1.5	0.6
Lin. Coef. of Ther. Exp. 10-5 in/in/°C	D696	3.8	8.1	10	3.8
Chemical Resistance					
Acids		Excellent	Attacked	Attacked	Good
Bases		Excellent	Attacked	Excellent	Attacked
Solvents		Good	Excellent	Good	Good
COST					
Cents/lb		36	65	98	22
Cents/cu in		1.5	3.3	4.0	1.2

[a] Injection molded specimens at room temperature
[b] Crosshead speed 1/min
[c] Crosshead speed 0.2/min
[d] Crosshead speed 0.05/min

AVISUN announces four new impact grades of polypropylene

Here, for the first time, are new impact grades of polypropylene—all possessing a translucent white resin color—with flow rates suitable not only for injection molding, but also for sheet extrusion, vacuum forming and blow molding. All four retain desirable properties characteristic of general purpose polypropylene—lightness, low cost, high heat and chemical resistance. *But each grade offers a step-up in impact strength at room temperatures.* Equally important, most of this strength is retained at lower temperatures—in the case of High Impact Grade 3210, as low as 10°F.

AviSun technical specialists can help if you plan to use a new AviSun impact grade of polypropylene for *your* product. For full technical data or counsel, write to us.

SPECIAL PROPERTIES

Property	Impact Grade 3116	Impact Grade 3216	High Impact Grade 3211	High Impact Grade 3210
Izod Impact Notched—ft-lb/in Unnotched	1.5 over 16	2.0 over 16	10 over 16	15 over 16
Flow rate—gm/10 min (nominal)	5.0	5.0	0.7	0.5
Type of molding	injection	injection	sheet extrusion vacuum forming	blow

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In an important advance stemming from extensive research, AviSun introduces the first high molecular weight polypropylene pipe grade resin combining low cost with excellent properties. It has been broadly tested with highly satisfactory results. AviSun pipe grade resin can be processed in most conventional plastic extruders—at rates equal to or greater than that of linear polyethylene. Its high per-pound yield makes it one of the most economical plastics.

Because of the attractive properties, pipe from this resin should yield optimum performance in such applications as: salt water disposal lines; gas gathering and distribution systems; crude oil flow lines; conduit; municipal water systems; process lines for organic and inorganic chemicals; automotive and aircraft tubing, and many others. For more data on AviSun polypropylene 1051 pipe grade resin, fill in coupon.

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Speaker vents spaced 0.020", molded-in snaps, and thin-section self-hinge on battery door show the molding versatility of AviSun injection grade polypropylene. Custom molded for Motorola by Sinko Manufacturing and Tool Co., Chicago 31, Illinois.

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polypropylene self-hinge *won't break!*

Motorola chose AviSun polypropylene for the cases of their transistor radios for these good reasons:

UNIQUE FLEXIBILITY. Self-hinge characteristic is new in the plastics field . . . can be used to cut costs, speed assembly, improve designs on a wide range of cases, boxes, and receptacles.

HEAT RESISTANCE. Polypropylene will not soften or lose strength, even at temperatures close to 220°F.

TOUGHNESS. Has the resiliency to absorb dropping and rough handling without chipping, cracking, or breaking.

ECONOMY. Polypropylene, lightest of all plastics, gives high yield per pound. Takes texture, detail and speaker vents beautifully.

The same advantages that make polypropylene the choice for transistor radio cases can benefit you in *your* product. Call on AviSun for complete data on resin grades —and for expert technical assistance.

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Send me Booklet AP-601 giving full technical information on AviSun Polypropylene.

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COMPANY_____

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In Canada: *Courtaulds Plastics Canada, Ltd.*

Dr. C. S. Grove, Jr. *Project Director*
Prof. R. Ford Pray, III *Associate Project Director*
Syracuse University

Materials Design Handbook For Aerospace Vehicles

GOALS—METHOD—STATUS
of a literature research project of great importance to the reinforced plastics industry

On the basis of a recent survey study, "Information Requirements for Application of Non-Metallic Structural Materials to Aerospace Vehicles", it was concluded that a definite need exists for a design handbook and manual, specifically tailored for non-metallic engineering materials applications in aerospace vehicles for the Air Force. Many contacts (some 250 personal and many more by mail) in industry agree that a comprehensive effort is needed to produce such a handbook. Since this effort is intended to fulfill the needs of all types of engineers involved in aerospace vehicle design work, its wide potential acceptance and use is indicated. As a result of the current rapid growth of highly specialized materials and design procedures for Air Force applications, the engineers involved in this field must be able to secure pertinent reliable information quickly.

The task of obtaining, organizing and correlating the immense amount of data available from scattered sources into a Materials Design Handbook, although a vast undertaking, can be accomplished. The need for order and the whole problem of the design and use of non-metallic materials are such that a positive effort will definitely be a great improvement over existing conditions. The amount of data available is increasing every day and the task of compiling this information into a handbook becomes more difficult as time goes on.

The survey study showed that inclusion of the following features will insure its use and acceptance:

1. Initial limitation of data and information to specific applications within the field of aerospace vehicle design for Air Force programs (such information will obviously be of great value to other design problems and material applications);
2. Provision for rapid dissemination of handbook sections to provide up-to-date information as advancements and improvements render current data obsolete in a short time;
3. Provision for constant revision and updating of previously published handbook sections;
4. Format design to provide for 1 through 3 above;
5. Format design to provide the greatest possible ease of use of handbook;
6. Provision for data and information in the handbook on all of the following:
   a. General information and application of materials,
   b. Design considerations for specific applications, including human factors where pertinent,
   c. Properties of primary materials,
   d. Properties of material systems,
   e. Stress analysis for specific applications,
   f. Processing and tooling information and their influence on properties and design,
   g. Testing and quality control;
7. Provision for adequate editorial coverage by experts from various industries and agencies;
8. Provision for adequate data and information collection, evaluation, correlation, utilization and dissemination; and,
9. Provision for full, direct and rapid coordination of all handbook sections during all phases of processing and dissemination.

Method

The handbook should be divided into a series of DIVISIONS, each organized for a specific material classification, see *Table 1*. Because of the complexities within one material classification, further division into MANUALS appears desirable *Table 2*, to facilitate use.

All evidence indicates that the general material classification of *STRUCTURAL PLASTICS* is the first handbook DIVISION of immediate importance. Furthermore, to alleviate problems, it has been decided to cover only the elemental structural applications of reinforced plastics initially, namely: laminates and wound open end cylinders. Adequate coverage of these will permit an approach similar to that of a machine design text book (with respect to basic design and stress analysis) in that from laminates sandwiches will be developed; from open end cylinders, wound "bottles" will evolve; etc.

Projected plans definitely call for later incorporation of sandwich construction, wound "bottles," secondary structures, adhesives, etc.

The fundamental need of the designer is for information relative to specific application of material systems. In non-metallics, material use and properties are closely tied to application, processing, and testing procedure. It is apparent, therefore, that information and data can be most appropriately organized by relating them

to a specific application or structure type, such as flat laminates or filament wound tubes, for example. To make the most useful presentation, MANUAL IB incorporates this "vertical slice" approach by being divided according to structure types. Therefore, this Manual will actually contain a series of correlated data write-ups, each including all of the Sections 1 through 8 indicated, and each concerned with only one specific structure type. Each write-up of a structure type in MANUAL IB will be documented and detailed as required by cross referencing to the subsequent MANUALS IC through IG which will cover specific topics more thoroughly than may be needed for actual design purposes. The key manual in the Handbook is, then, MANUAL IB which covers the various structure types and their application. The basic information presented in the other Manuals is definitely designed for complete Handbook coverage to amplify, support and clarify MANUAL IB]

Therefore, the following features are expected to be included in the Handbook to insure ease of write-up, organization, use, cross-reference and revision:

1. Standardized decimal system for paragraph identification;
2. Page format placing graphical or tabular information adjacent to corresponding descriptive text;
3. Material identification code indicating application, resin system, reinforcement and process;
4. Loose leaf binding.

DIVISION I of the Handbook will only be as valuable as the data incorporated therein. It is obvious, therefore, that the method of data collection, evaluation, filing and retrieval is very important to the whole handbook effort. The data collection procedure incorporates two files: 1) BCF—Bibliographic Card File; and 2) SDF—Specific Data File. The former provides ready access to general information on source, data, and type of data available; in other words, a "Source Who's Who". The specific data file catalogs all information into detailed classifications on large McBee Keysort Cards to permit rapid handling and correlation. A five digit random number coding has been adapted to identify in detail the following items concerning the specific information appearing on each card: material, process, property, test method, source, source date, source type, Handbook Division and miscellaneous items. It is estimated that some 35,000, or more, SDF cards will result from the first year's work. The random number coding, permits relatively simple conversion to microfilm (aperture card on roll) data filing with digital retrieval.

Information which will be incorporated in the Handbook is being obtained from: Government Agencies, Research Organizations, Producers, Fabricators, Users, and Published and Un-Published literature available and personal contacts.

To handle such an undertaking as described herein staffing and organization has been found to be very important. The Syracuse University project staff is currently working out

Table 1. Handbook Major Divisions

DIVISION I	—Structural Plastics
DIVISION II	—Structural Adhesives
DIVISION III	—Structural Ceramics
DIVISION IV	—Other Structural Non-Metallics
DIVISION V	—Structural Combinations of Metallics and Non-Metallics
DIVISION VI	—Secondary Structural Components
DIVISION VII	—Non-Structural Applications (Insulations, Coatings, etc.)

Table 2. Division I Manuals

DIVISION I—STRUCTURAL PLASTICS

MANUAL 1A—INTRODUCTION
- Section 1. Purpose of HANDBOOK DIVISION I
- Section 2. Summary of DIVISION I Contents
- Section 3. How to Use DIVISION I, including explanation of structure classification system abbreviations
- Section 4. Summary of Applicable Specifications
- Section 5. Abbreviations
- Section 6. Glossary of Terms
- Section 7. Index of Structural Applications
- Section 8. Index of Materials
- Section 9. Source References

MANUAL IB—BASIC DESIGN
- Section 1. Introduction
- Section 2. Design Considerations
- Section 3. Primary Materials Summary
- Section 4. Material Systems Summary
- Section 5. Stress Analysis
- Section 6. Processes
- Section 7. Tooling
- Section 8. Testing and Quality Control

MANUAL IC—PRIMARY MATERIALS AND THEIR PROPERTIES
- Section 1. General
- Section 2. Physical and Chemical Properties
- Section 3. Mechanical Properties
- Section 4. Manufacturing Characteristics

MANUAL ID—MATERIAL SYSTEMS AND THEIR PROPERTIES
- Section 1. General
- Section 2. Physical and Chemical Properties
- Section 3. Mechanical Properties
- Section 4. Manufacturing Characteristics

MANUAL IE—THEORETICAL STRESS ANALYSIS
- Section 1. Introduction
- Section 2. Laminates
- Section 3. Wound Cylinders

MANUAL IF—PROCESSES AND TOOLING
- Section 1. Introduction
- Section 2. Laminates
- Section 3. Wound Structures

MANUAL IG—TESTING AND QUALITY CONTROL
- Section 1. Introduction
- Section 2. Destructive Tests
- Section 3. Non-destructive Tests
- Section 4. Quality Control Procedures

of a suite of recently remodeled offices. Space and manpower are being added as rapidly as required. To supplement the operation of the staff at the University, a number of consultants throughout the country have volunteered their services.

Status

Currently the Specific Data File has some 2000 cards in process with about 200 added each working day. Data are flowing in from a wide variety of sources and includes such items as reports; various government and company material and process specifications; test reports on primary materials, material systems, and finished products; test data never before published; and design procedure and stress analysis information, which form the "backbone" of the whole Handbook effort.

A variety of material systems is planned for coverage in the First Edition. A general summary of these is shown in *Table 3*. It should be pointed out that the number to be covered in the first writing is limited. An attempt is being made to include only those systems of most important current use in actual production structures. Many more systems will be covered in revised editions.

The authors desire to receive any and all comments on constructive criticisms on the work which they have undertaken. Any specific data which will "fit" into the handbook will be used as applicable. It will be impossible to achieve the project goals with their resulting benefits to industry without the encouragement and assistance of government agencies, material producers, fabricators, designers, research organizations, and end product users.

For direct information and submission of data for the Materials Design Handbook either of the authors can be addressed personally care of:

P.O. Box 145
University Station
Syracuse 10, New York

Editor's note: Why waste time—Let them hear from you now!

Edited by
George Lubin
Grumman Aircraft Engineering Corp.

Table 3. Summary of Material Systems Initially of Interest to Handbook

Resin					Process	
Type	Examples*	Curing Agent	Reinforcement Type*	Finish	Type	Wet or Prepreg
POLYESTER						
1	Paraplex P-43 Selectron 5003 Laminac 4128 CFR	—	181 Glass cloth	Volan Garan	Vacuum Bag	Wet
2	8000 Mod Laminac 4171	—	181 Glass cloth	Volan	Vacuum Bag	Prepreg
3	Paraplex P-43 Laminac 4128	—	"E" Glass roving	Volan	Filament Winding	Wet
EPOXY						
1	Epon 828 ERL 2774	CL or RP7A	181 Glass cloth	Volan	Vacuum Bag	Wet
2	Epon 828 BX-165	RP7A or CL	181 Glass cloth	Volan	Vacuum Bag	Prepreg
3	Epon 828 or 826 Scotchply 1001	RP7A or CL RD3-24	"E" Glass roving	Volan	Filament Winding	Wet or Prepreg
PHENOLIC						
1	F-120 V-204 91 LD SC 1008	—	181 Glass cloth	Volan	Vacuum Bag Autoclave Press Molded	Prepreg
	101 17085		181 Glass cloth chopped ("wheat chex")	Volan	Matched Metal Die	Prepreg
2	MX 2625 91 LD SC 1008	—	181 "Refrasil" cloth Refrasil cloth chopped ("wheat chex")		Press Molded Matched Metal Die	Prepreg Prepreg
EPOXY-PHENOLIC						
1	ELS 0703	—	181 Glass cloth	Volan	Autoclave	Prepreg
2	438 + MNA + BDMA	—	"E" Glass roving	Volan	Filament Winding	Wet
3	Scotchply 1009	—	"E" Glass roving	Volan	Filament Winding	Prepreg
PHENOL-SILANE						
1	SC 1003 37-9X	—	181 Glass cloth	Volan	Vacuum Bag Autoclave	Prepreg
SILICONE						
1	DC 2106	—	181 Glass cloth	112 NPH	Vacuum Bag Autoclave Press Molded	Prepreg or Wet

* A few manufacturer's catalog names or numbers are listed as examples and the listing is not intended to be all inclusive. Any other material leaving comparable properties will definitely be included in the handbook write-ups.

DOW PLASTICS TECHNICAL FILE

SELF-EXTINGUISHING EPOXY RESINS

The use of versatile epoxy resins based on bisphenol A and epichlorohydrin will be considerably broadened by the recent Dow development of self-extinguishing epoxy resins. Dow Research elected to introduce halogen directly into the epoxy molecule, instead of using halogenated curing agents or depending on fillers to attain this characteristic. With the resin contributing the self-extinguishing properties, epoxy formulators are free to utilize any curing agent and filler systems needed for the host of epoxy end uses.

This approach, halogen on epoxy, is not a new approach to self-extinguishing characteristics, but in the past has generally resulted in too great a sacrifice of other physical properties. The new Dow epoxy resins containing bromine, however, provide excellent self-extinguishing properties with *little or no loss of other desirable properties.*

Ordinarily, a bromine content of 15-25% will render even an unfilled casting suitably self-extinguishing. Of course, variation in curing agents, concentration, addition of fillers and fibers, and variations in operating environment will require deviations in the bromine content range.

Two brominated epoxy resins are offered by Dow: Experimental Resin X-3442, a semisolid; and X-3441.1, a solid, similar in physical form to D.E.R.® 661 resin. Physical properties of these resins are given in Table I.

Experimental Resin X-3442, with nearly 50% bromine by weight, is designed for blending with other resins. Test data on castings were determined using blends of 50 parts X-3442 to 50 parts D.E.R. 331. Experimental Resin X-3441.1 can be used either alone or in blends with conventional resins such as D.E.R. 661 resin. It has particular utility in pre-preg laminating since it handles by conventional methods in use for standard solid epoxies. The testing of X-3442 and X-3441.1, and of their blends with other epoxies, revealed that physical properties developed by these brominated resins are very similar to those developed by conventional epoxy resins, except in isolated cases with specific curing agents. In the case of clear castings of 50/50 X-3442 and D.E.R. 331, a loss of flexural strength was found at 300 F. However, standard epoxy resins show similar losses at this temperature, with identical curing agents.

It can be concluded from the studies that the Dow self-extinguishing epoxy resins can replace enough conventional epoxy in any formulation to provide self-extinguishing characteristics, with little or no degradation of the mechanical or electrical properties. Partial technical information obtained during the tests is reproduced below.

For full data and information on the Dow experimental self-extinguishing epoxy resins, write Coatings Materials, Plastics Sales Department 1956EX11.

TABLE I

Physical Properties of Experimental Self-Extinguishing Resins*

Experimental Resins	X-3442	X-3441.1
Physical Form	Semisolid	Solid
Viscosity 150°F, cps.	160,000	—
25°C, 80% N. V. in MEK, cps.	—	3,120
Durrans Softening Point, °C	53	73.5
Epoxide Equivalent Weight	365	476
Specific Gravity 25/25°C	1.79	1.40
Color, Gardner	11	—
80% N. V. in MEK	—	6-7
Bromine Analyzed, %	48.7	18.7

*These are typical properties, not specifications.

TABLE II

Physical Properties of Typical Unfilled Castings Formulations

Formulation Resin	D. E. R. 331	X-3442/D. E. R. 331 50/50
Hardener, Conc. phr	NMA/BDMA-86/1.5	NMA/BDMA-62/1.5
Gel Time, 50 gm. at 212°F	—	19 min.
Post Cure	4 hrs @ 175°F+ 15 hrs @ 300°F	4 hrs @ 175°F+ 15 hrs @ 300°F
Physical Properties		
Heat Distortion Temp., °F	284	286
75°F Flexural Strength, psi	14,300	15,800
Modulus	$.487 \times 10^6$	$.473 \times 10^6$
300°F Flexural Strength, psi	880	550
Modulus	$.470 \times 10^4$	$.287 \times 10^4$ *
75°F Compression Strength, psi	37,500	37,750
Modulus	$.407 \times 10^6$	$.399 \times 10^6$
300°F Compression Strength, psi	32,000	33,000
Modulus	$.750 \times 10^4$	$.651 \times 10^{4}$**

*Yielded, but did not break
**Compressed 50-75% before disintegrating
NMA—NADIC methyl anhydride
BDMA—Benzyldimethylamine accelerator

TABLE III

Self-Extinguishing Characteristics of Typical Pre-preg Laminates

(Curing agent—dicyandiamide)

Resin System	Ratio	ASTM D-635 Burning Time, Seconds
X-3442/D.E.R. 661	20/80	0-5
X-3442/D.E.R. 661	30/70	1-5
X-3441.1	100	—
X-3441.1/D.E.R. 661	75/25	1-3
X-3442/D.E.R. 661	20/80+ Antimony Oxide	0-4
X-3442/D.E.R. 661	15/85+ Antimony Oxide	7-12
Curing agent, MDA, 29 phr, wet lay up		
X-3442/D.E.R. 331	50/50	0-1
Curing agent, BF_3-MEA, 3 phr, wet lay up		
X-3442/D.E.R. 331	50/50	0-1

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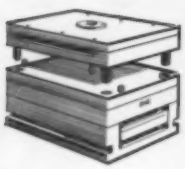

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MOLDMAKING

Five New Parts— For Better Molds

Some tips on mold design. Five methods based on the utilization of new auxiliary parts are outlined here

Worthy of consideration by mold designers, mold makers, and molders are auxiliary type parts, which can be used to simplify mold design, construction and maintenance. Each has been found to be satisfactory in actual mold construction and operation. They were utilized primarily in multi-cavity injection molds but are equally applicable in other types of molds when properly employed.

Disc Springs

Disc springs are ideal for use in plastics molds where it is necessary to concentrate power in a small space, for load dissipation or for damping purposes. They are used in place of the common coiled round or rectangular wire die springs.

The usual form of disc springs is the straight conical plate with rectangular cross section as shown in *Figure 1*. The greatest tension occurs on the inner rim, falling off rapidly toward the outer rim. This characteristic gives the spring good resistance and the danger of settling is extremely small. Good damping results from friction between the multiple stacked disc springs.

The spring characteristic is dependent on the ratio of the clear height and the material thickness. Relatively thick springs give an almost straight load/deflection curve. The characteristic curve of this spring is regressive, falling away more or less rapidly or even returning.

The load/deflection curve of the springs is primarily dependent on the modulus of elasticity of the steel employed; good quality steel is especially important in relation to endurance. Steel of good quality permits high stressing of the spring and facilitates a compact design of the spring. Disc springs are shot blasted to give increased life. *Figure 2* shows stacked uncompressed and compressed disc springs.

The size of disc springs from one manufacturer range from ⅜" O. D. to 2⅜" O. D. The pressure resulting from .75 deflection of a ⅜" dia. spring is 57 lbs. while that of a 2⅜" dia. spring is 2,375 lbs. with comparable pressures for diameters in between. The diameter of the hole in the disc spring is clearance size for common diameter guide rods.

The springs may be safely pressed to flatness by static loads. By rarely occurring traction loads, the springs may be compressed from 70-80% of their total deflection. By normal dynamic loads the springs may be compressed from 40-50% of their total deflection. When dynamic loads change continuously from 0 to large loads or when there are a large number of oscillations per minute approximately 2/3 of the normal dynamic compression should be used.

Disc springs have been successfully employed as "take-up" springs for applications involving "stack-up" problems or shock loading. The springs of lighter thickness are used to take up axial clearance and to reduce noise in ball bearings.

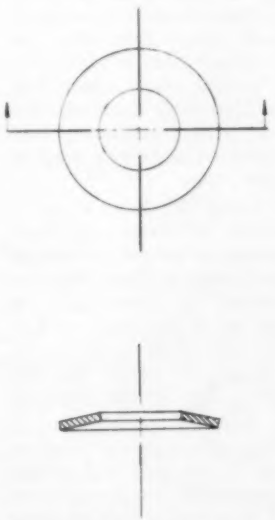

Figure 1. Usual form of disc spring

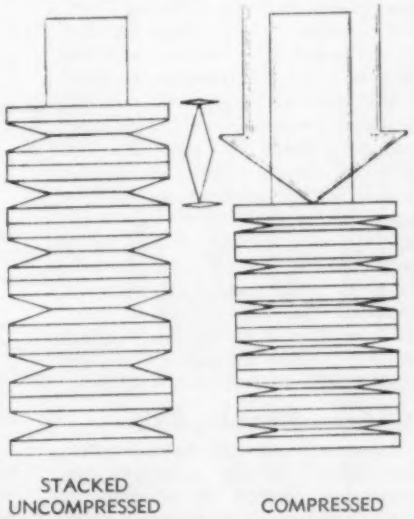

Figure 2. Stacked disc springs, uncompressed and compressed

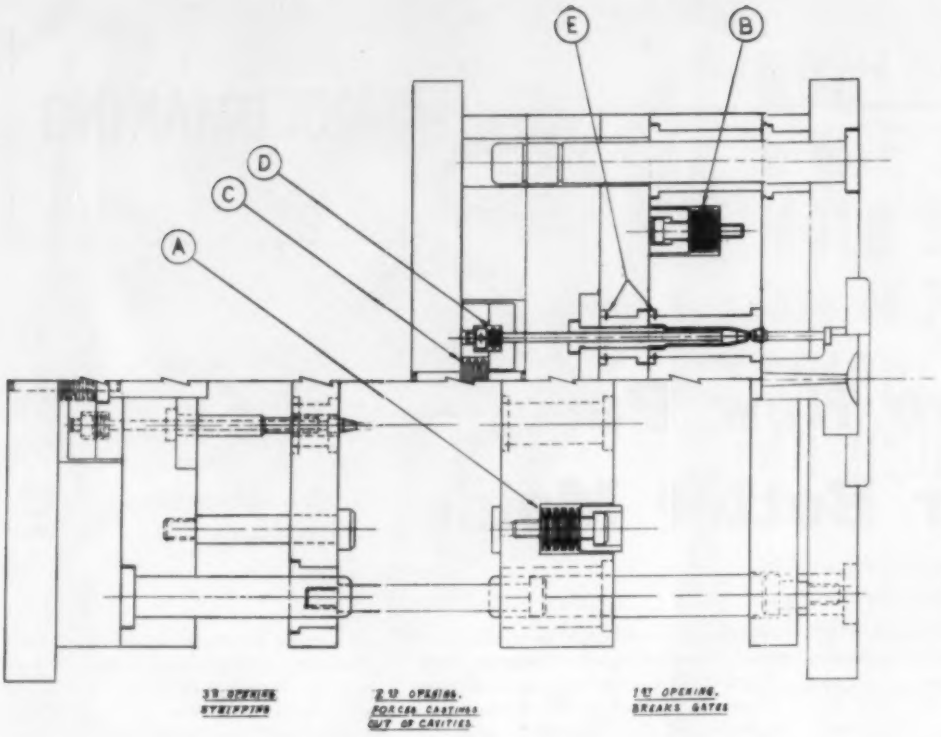

Figure 3. Cross-section of an injection mold in which various disc and retaining rings springs are used

Disc springs are not the simple washers they appear to be and when properly utilized within the recommended loads maintain their given values for unlimited life. They do not require settling time, and save valuable construction space.

Figure 3 shows the cross-section of an injection mold in which disc springs of various diameters and varying metal thicknesses have been utilized to perform different jobs. Four groups of ¾" diameter disc springs at detail "A" with a combined force of 1,416 lbs. separate the mold at the "first opening," which breaks the gates. Two groups of ¾" diameter springs at detail "B" exert 500 lbs. to "break" the parts out of the cavities at the "second opening" point. Two groups of ¾" diameter springs at detail "C" exert a force of 332 lbs. to assist the ejection of castings from the cores at the time of the stripping operation. On each core pin at detail "D" are ⅜" diameter disc springs utilized to "take-up" various core pin lengths and accumulated tolerances.

"C" Shape Retaining Rings

A precision stamped metal product, this spring, provides a modern and economical method of retaining or positioning mold components. "C" shape retaining rings are designed for internal or external applications and are available in four metal materials and various finishes. They range in size from .125" to 10.000" in diameter. *Figure 4* shows those most frequently used internally and externally.

The "C" shape retaining ring is finding increasing applications in retaining cylindrical cavities, core pins, stripper bushings, ejector pins, rotating shafts and other mold parts. Their use in molds eliminates the necessity for backing plates or inset plates used to retain mold components. They are most useful for retention of mold components in floating plates where it is desirable to keep plate thickness to a minimum or where machining thin plates for inset retainers may weaken or distort the plate.

Figure 3 detail "E" shows a typical mold in which retaining rings have been employed to retain the cavity and stripper bushing. Note that the force subjected by "breaking" the molded part out of the cavity and of stripping the part off the core is born by the head of the cavity and the bushing rather than by the retaining ring.

One of the advantages of using retaining rings is the ease with which one mold component may be removed or inserted in a mold. Special pliers are used to assemble or remove the "C" shape retaining ring. *(Figure 4)*

Flat Spiral Retaining Rings

Precision manufactured rings from flat spring steel are coiled on edge to effect a 360 degree retaining surface, useful for retaining or positioning rotating or non-rotating mold components. They are inherently balanced rings without lugs, as shown in *Figure 5*, needing no special tools to remove or install. They are re-usable, lock under load in the groove and will resist thrust forces without jumping out of the groove up to the shear point.

The rings are available in single, double or triple turns for light, medium or heavy duty applications respectively. Standard range of sizes available are from ½" to 11" diameter shaft or housing.

At least one supplier of mold bases and mold components is using flat spiral retaining rings to act as the

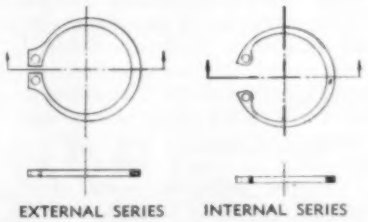

Figure 4. "C" shape retaining ring

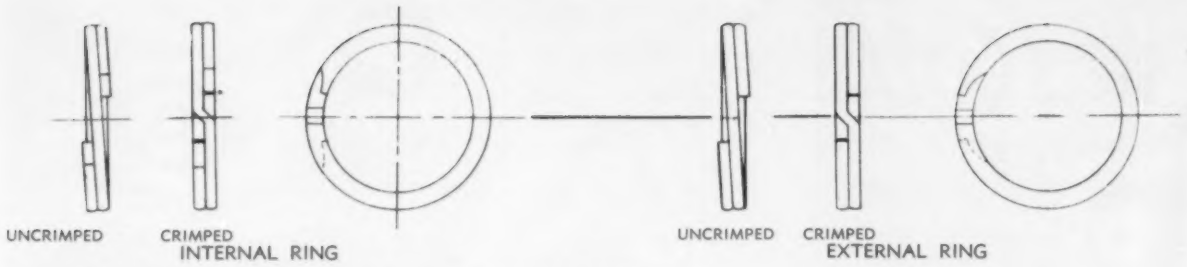

Figure 5. Flat spiral internal and external retaining rings

head for long length, large diameter, leader pins. This cuts down the cost of manufacturing such pins with integral heads.

Special flat spiral retaining rings are available for high rotative speeds, for applications involving shock loads or for applications where grit or foreign material will force conventional rings from the grooves. Also available are resilient "take-up" rings for applications involving "stack-up" problems or shock loading.

Split Ring Clamp

Especially useful in retaining core pins, rotating mandrels, and other mold components is the split ring clamp as shown in *Figure 6*. This clamp is most beneficial with long core pins which would normally require extensive machining to form a retaining head, or with core pins having a larger diameter body than shank and which require threading through small diameter bushings at assembly.

The clamp is composed of hardened split half-rings which lock into a slightly reduced diameter of the shank. The hardened ring slides over the split halves to lock the split halves firmly on the core pin.

Figure 6 shows the application of a split ring clamp in an actual mold design. The mandrel in the mold rotates at moderate speed on the opening stroke of the mold. The split ring clamp holds the mandrel in position during this operation.

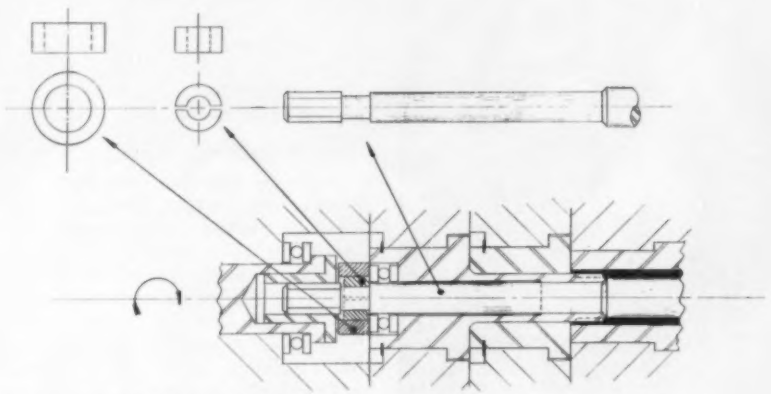

Figure 6. Split ring clamp in use

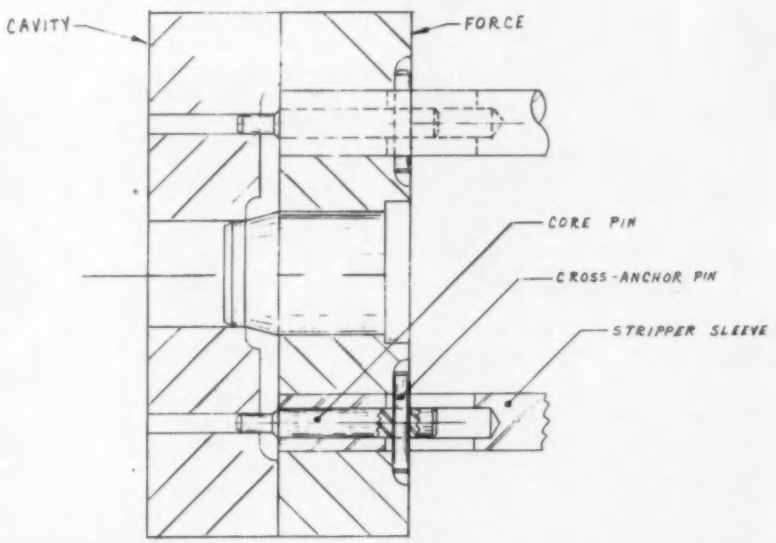

Figure 7. A simplified core pin used for positive ejection of molded parts where short core pins are required

Simplified Core Pin

If a positive method of ejection of the molded part off the core pin is necessary where short length core pins are required, the design in *Figure 7* has been found to be a satisfactory way of handling this problem.

This design permits the use of an extremely short core pin which is retained between the bottom of the cavity and the cavity back-up plate by a short cross-anchor pin which extends through the shank of the core pin. The stripper sleeve need be bored only to the depth sufficient to accommodate the length of the shank portion of the core pin and the stripping stroke. Slots in the side walls of the stripper sleeve are required for clearance of the core pin cross-anchor pin. The core pin is held in proper hole alignment at all times by the sliding fit of the core pin in the stripper sleeve.

The particular design has been used in a multicavity mold for several million parts molding polyethylene material.

—— ■ ——

Edited by
John A. Kavanagh
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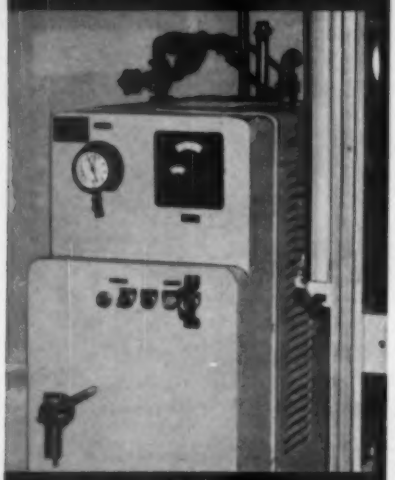

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Industrial Control Division

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Speaking of Extrusion

(Continued from page 1176)

reduction that is actually being afforded and to share the results of a more uniform production with the customers. The amount of reduction possible on a given process depends primarily on the thickness distribution bandwidth of the original control method vs how closely a radioisotope gauging system is able to maintain the bandwidth on the same process. Generally, the reduction of process variations through the use of this equipment has been in the area of 40 to 50% allowing reduction in average thickness or weights that more than justify its purchase.

More Pounds Per Year

Increased saleable production, reduction in machine costs, reduced reject or marked down material, etc. are all possible with better quality control. Increases in efficiency and operating control of a process allow the manufacturer to produce more in a given period of time than he could produce by conventional control methods, in addition to reducing the amount of off-grade or reject material. Process down-time is also reduced e.g. bubble breaks on a tubular film extruder when these breaks are related to severe thickness variations in the film. The use of radioisotope non-contacting thick ness gauges also allows reaching specification thickness faster at start-ups and during production order changes. These all add up to production time and material savings which, when looked at over a year or more operating time, can result in considerable dollar savings. With assumed process operating expenses, scrap records, and raw material costs, the magnitude of these savings can be readily calculated. The reduction of reject material in other following operations, such as a slitter and rewind section, or a vacuum forming operation, can also be sizable and result in additional savings that are the direct result of using a thickness control system to produce a more uniform sheet or film product.

Engineering Tool

Other benefits which, for a particular installation may be as important or even more important than those previously mentioned, include the use of the system as an engineering aid and a trouble shooting tool. Troubles which result in the extruder process invariably are reported immediately by these systems as variations in product weight or thickness. Often these variations are of such a nature that the system recorder actually leads to the solution of the problem. A faulty heater in the die of a sheet extruder has been indicated by poor profile control on the system recorder. Problems with air rings on blown film extruders have been observed by the thickness measuring system. Often times the observed product variations are cyclical in nature or have other characteristics which lead to rapid analysis of the trouble. A polystyrene sheet extruder with out-of-round chill rolls produced extreme cyclical variations on a thickness control system recorder and led directly to the solution of the problem. The cyclical variations indicated on the recorder chart were found to correlate closely with the rotational speed of the chill roll. Use of the system in this area should not be overlooked.

In the field of new process or product development, thickness measuring systems have often been used for their accuracy and ease of collecting information to aid in the development of the process.

Conclusion

In short, the radioisotopes noncontacting thickness control system now permits accurate, reliable, continuous measurement for plastic sheet and film processes. In so doing, it opens up many avenues to a precise and scientific approach to the engineering and control of both new and old processes and products alike. It allows the extruder to produce a product of maximum thickness uniformity at minimum cost. This high product uniformity can be of considerable importance to those utilizing the sheet and film in the packaging field. It too will allow them to produce a higher quality product with reduced costs. Such systems are not the cure-all to all extruder problems. Such systems incorporate no magic, but are specially designed and engineered systems developed to do a specific job on a specific process. It has, however, brought about a measure of progress in the plastics extrusion industry that only a few years ago would not have been possible. It is anticipated that the use of non-contacting thickness control systems in the plastics industry will keep pace with the anticipated growth of the industry itself.

—— ■ ——

Edited by
Bruce Maddock
Union Carbide Plastics Co.

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Plastics Institute of America Announces Program

Tom Zawadzki,
Executive Secretary
Plastics Institute of America

At a press conference held in New York City on September 15, 1961 the newly incorporated Plastics Institute of America made these disclosures:

- A number of firms have already accepted the Institute's invitation to join as Charter Members. These include Buckeye Cellulose Corporation, Memphis, Tenn., a division of Proctor & Gamble, Inc.; Southern Plastics Company; and the Plastics Division of U.S. Plywood Corporation. All firms in the plastics industry that have expressed an interest in the Institute's program and a willingness to support its activities are currently being canvassed.
- An executive secretary, to work full-time on the Institute's affairs, has been appointed. He is Tom Zawadzki, presently group manager of the Polyvinyl Chloride Department of Borden Chemical Company, Leominster, Mass., and previously vice-president in charge of research and development for Cary Chemicals, Inc., East Brunswick, New Jersey. Mr. Zawadzki, who was introduced at the conference, will assume his new responsibilities on October 15.
- The initial research program has been mapped.
- The process of selecting the educational institution with which the Institute will affiliate for carrying out its educational objectives, its research program, and its technical information and library service, is already underway. Dr. Frank Reinhart, chief of the Plastics Section of the National Bureau of Standards, who is directing this selection-process, described the method by which the capabilities, special facilities, and degree of interest of a large number of such institutions in this country are being "screened" and evaluated by the entire Board of Trustees. This step, he pointed out, cannot be hurried, and should not be, since it need not be completed before the Institute actually commences its activities.

A temporary board of trustees, who will serve until the first permanent board is elected, includes:

Jules Lindau, President of Southern Plastics Co. Mr. Lindau was Secretary of SPE in 1955.

Emil Ott, Rutgers University, and formerly vice president for research and development for the Chemical Division, FMC Corp.

Frank W. Reinhart, Chief, Plastics Section, National Bureau of Standards. Dr. Reinhart was President of SPE in 1955 and is Chairman of SPE's Editorial Advisory Board.

Jerome L. Formo, formerly director of plastics research for Minneapolis-Honeywell Regulator Company and now vice-president of Plastics Corporation of America, Minneapolis. Mr. Formo was President of SPE in 1956.

A. A. Hutchings, vice president in charge of sales for F. J. Stokes Corporation, Philadelphia.

S. E. Q. Ashley, manager of General Electric Company's Major Appliance Laboratories, Louisville.

George Epstein, structures engineer for the Aeronutronic Division of Ford Motor Company, Newport Beach, California.

Prof. Louis F. Rahm, director of the Plastics Laboratory at Princeton University.

Samuel H. Greenwood, of F. J. Stokes Corp. is vice chairman of the SPE Engineering Board, National Councilman for The Philadelphia Section and Treasurer elect.

The research program, as announced at the press conference, is detailed below. The basic purpose of this program, it is reported, is to assist with technical knowledge all segments of the plastics industry for proper participation in the development of the industry and to promote the overall growth of the industry based on sound scientific and engineering data and understanding.

1. Collection and retrieval, critical evaluation of literature information. Includes data obtainable from companies and other industry associations.
2. Research on structure and chemical and physical properties of polymers and polymer systems.
3. Tabulation of properties which will enable proper engineering applications.
4. Critical evaluation and correlation of testing methods and development of new methods in order to arrive at objective and meaningful specifications.
5. Research on the fundamental causes of degradation of plastics.
6. Research on prevention of degradation by chemical modification or by use of additives, etc.
7. Investigation of processing properties of polymers to obtain optimum properties for design use.
8. Research on reinforcement.
9. Studies on adhesion and cohesion.
10. Evaluation of polymers and plastics as electronic materials.

Guiding principles are:

1. To carry on possible collective research too costly for individual companies.
2. To engage in research which is valuable on an industry wide basis and which avoids wasteful duplication when accomplished by the Institute.
3. To serve in the development of objective standards for the plastics industry.

The areas of research detailed above satisfy these conditions, in the opinion of the Board of Trustees.

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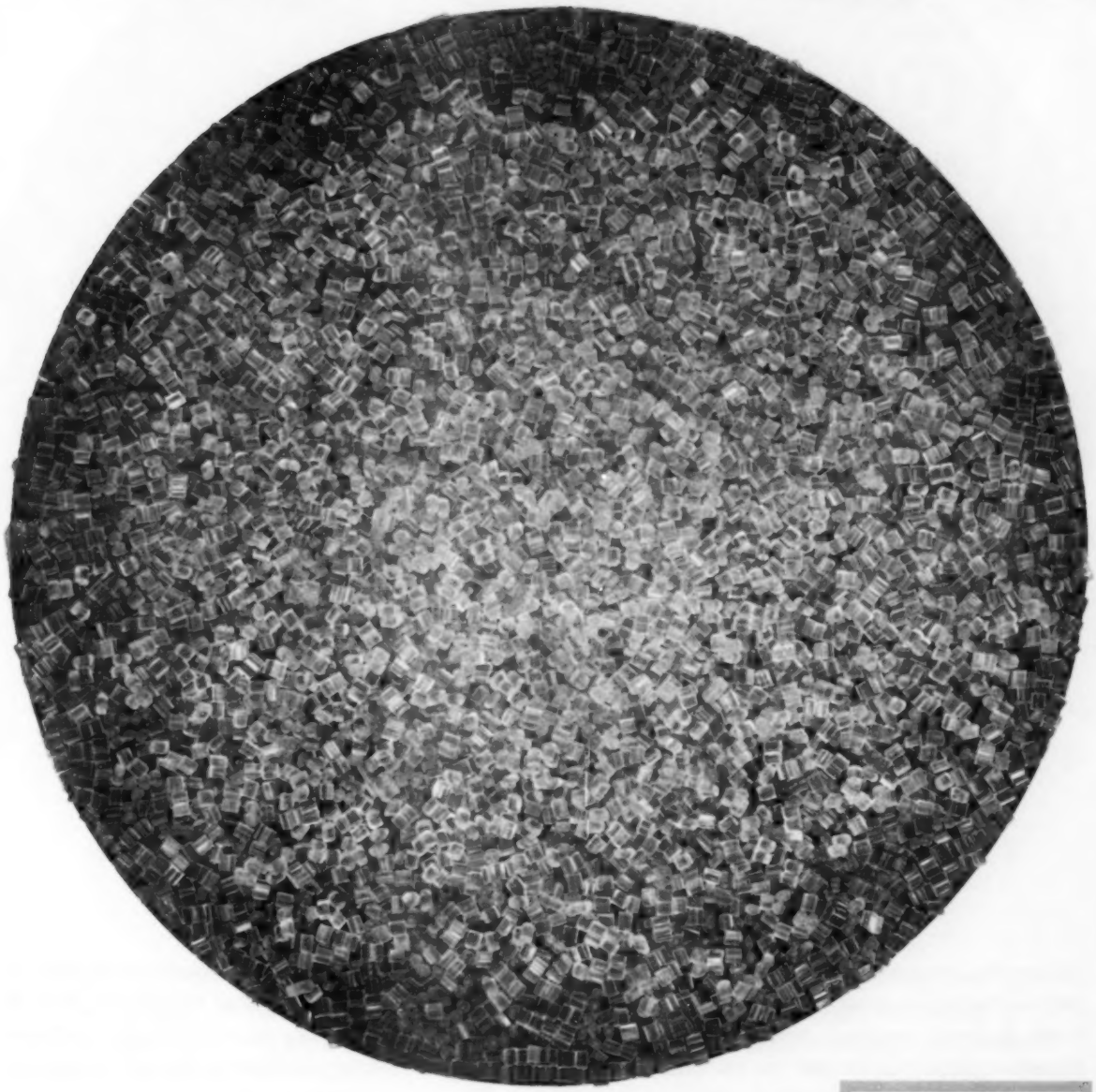

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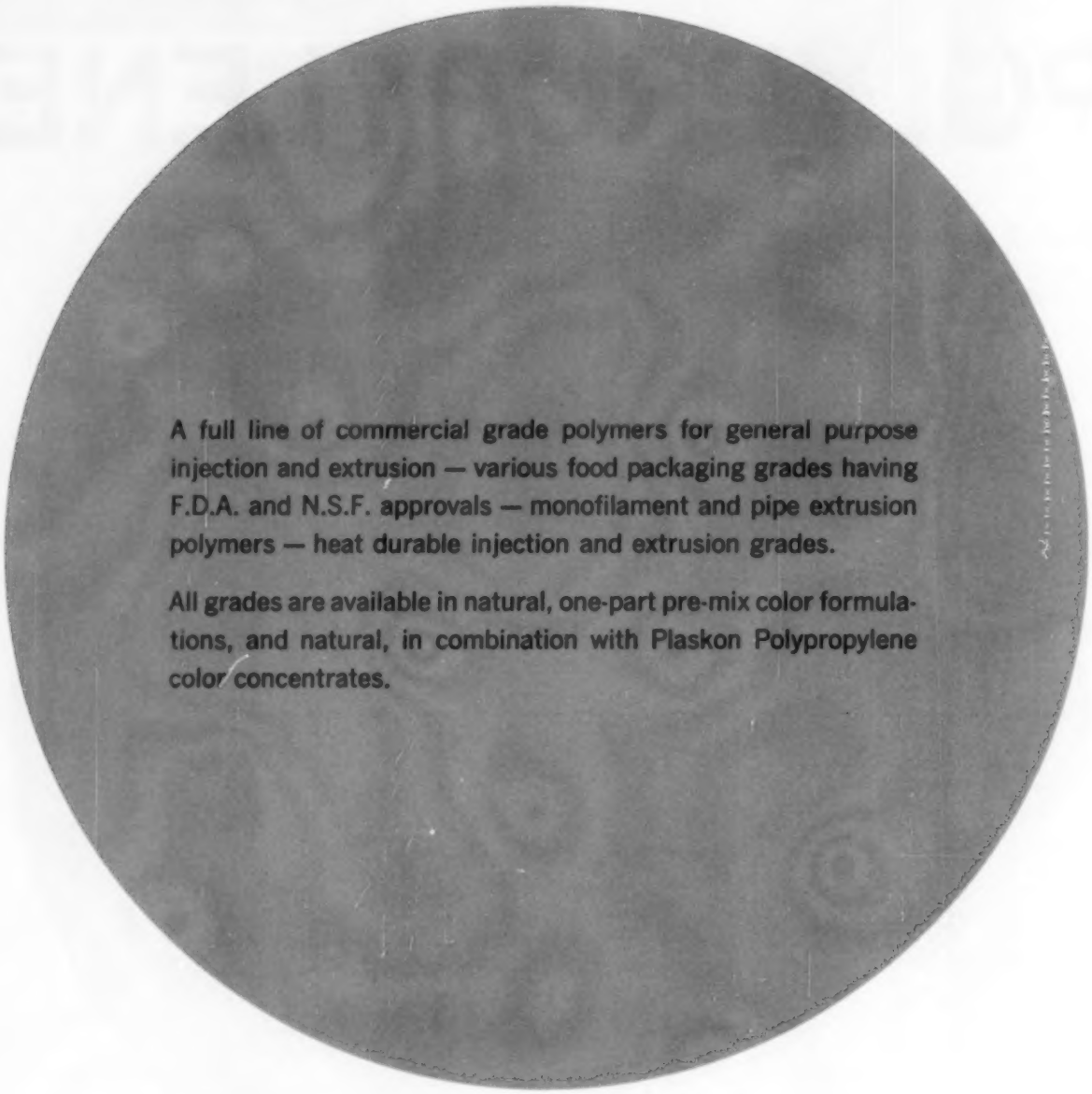

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Density	D-792-60T	GM/ML	0.91
Melt Flow Rate, 230°C., 2160 GM. Load	D-1238-57T (Modified)	GM/10 Min.	0.3-7.5(1)
Mechanical (At 73°F.)			
Tensile Yield Strength At 2 IN/MIN	D-638-60T	PSI	4900
Ultimate Tensile Elongation At 2 IN/MIN	D-638-60T	%	250
Stiffness—Flexural	D-747-58T	PSI	150,000
Impact Strength, Izod	D-256-56	FT/LB/In Notch	0.8-1.2
Hardness—Rockwell	D-785-60T	R Scale	92
Thermal			
Melting Point		°F.	346
Deflection Temperature Under Load			
66 PSI	D-648-56	°F.	245
264 PSI	D-648-56	°F.	145
Deformation Under Load 2000 PSI, 122°F., 24 Hrs.	D-621-59	%	3.0
Miscellaneous			
Environmental Stress Cracking	Bell. Labs. Test		None

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A New Catalyst for Urethane Foams

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Evaluation of a chelated stannous catalyst in urethane foams has shown it to be superior to standard tin catalysts in storage stability and oxidation and hydrolysis resistance

Within a few years, flexible urethane foam technology has evolved from polyester based foams through various stages of polyether prepolymer type foams to one-shot polyether foams. This development has been accompanied by great improvements in physical properties of the foams and in economy by reduction in foam density. One important advance during this time was the introduction of tin catalysts which made the large scale production of one-shot polyether foams possible.

Catalyst Properties

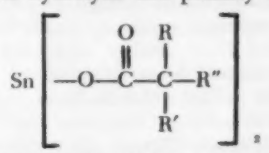
The hydroxyl-isocyanate reaction is catalyzed by a large variety of compounds (1). However, in practice, only a relatively limited number of compounds have the required combination of properties to make them suitable for foam production. These requirements include a strong catalytic effect for the hydroxyl-isocyanate reaction to promote rapid viscosity buildup and polymer growth and only a relatively minor effect on the water-isocyanate reaction resulting in gas formation (reaction of water-isocyanate). Since these two reactions normally occur at different rates and the rates change to a different degree with changes in temperature, the correct balance of reactivity is not readily achieved; to achieve this end a proper catalyst system is necessary.

Additional desirable attributes of a catalyst are lack of toxicity, lack of odor and absence of catalytic effects leading toward degradation reactions, such as oxidation and hydrolysis, in the finished foam.

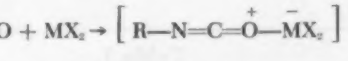
Two types of tin catalysts have met these conditions to a sufficient degree to gain commercial acceptance, viz.. (1) dialkyltin salts of organic acids [$R_2Sn(OCOR')_2$] such as dibutyltin dilaurate, and (2) stannous salts of organic acids [$Sn(OCOR)_2$] such as stannous octoate. Many compounds in these groups have generally equal catalytic activity. These types of tin compounds have disadvantages however. The dibutyltin salts contribute to poor dry-heat aging stability of foam (by catalyzing oxidation). The dibutyltin salts and to a lesser extent the stannous salts act synergistically with amine catalysts and require these to give a correct balance in the foaming reaction. Both types of tin salts, especially the stannous salts are readily hydrolyzed and oxidized. These properties lead to difficulties in batch to batch control of reactivity and result in poor storage stability of the catalysts and especially of premixes used in foam production. Also both types of tin salts react with the silicone polymers generally used as dispersing agents making it necessary to keep these two ingredients separated until just prior to foaming.

Two general approaches were investigated in order to improve resistance to oxygen and moisture, while at the same time maintaining the required catalytic activity.

Stannous Salts of Sterically Hindered Organic Acids to reduce the rate of hydrolysis and possibly the rate of oxidation.



The great resistance to hydrolysis of sterically hindered esters is well established (2). At the same time, this type of steric hindrance should not interfere with the proposed mechanism of catalysis by tin salts since the steric hindrance



does not affect the availability of the tin.

An example of this type of compound, stannous dimethylvalerate, was found to be an excellent urethane catalyst with slightly better resistance to hydrolysis than stannous octoate (3). The observed difference, however, was only one of degree and not of kind. Since the improvement was not sufficiently large, another approach was tried.

Chelated Stannous Salts should be more resistant to oxidation and possibly to hydrolysis than the usual stannous salts.

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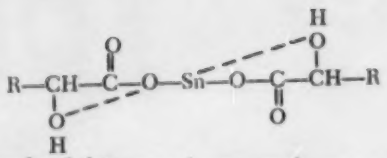
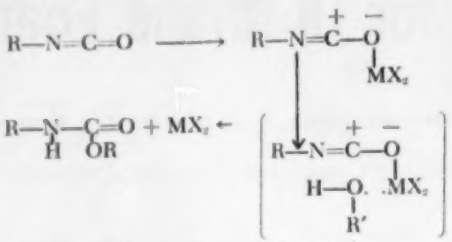
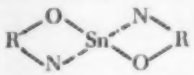


An example of this type of compound, stannous tartrate, was found to have greatly reduced catalytic activity and was therefore not usable. Similar complexed salts which show only slight catalytic activity are the metal acetylacetonates (3). The reduced catalytic activity is presumably due to interference with the establishment of a Sn complex with the NCO group as shown above or due to unavailability of the Sn for interaction with an OH group from the polyether.



Surprisingly, another type of chelated stannous complex was found to have catalytic activity of the same order of magnitude as stannous octoate and dibutyltin dilaurate. This material differs from those previously investigated in that the chelation involves at least one nitrogen atom instead of all oxygen atoms, e.g.



In light of the proposed mechanisms for the interaction of Sn catalysts with NCO groups, this activity is not readily explained because this type of compound should not interact easily with NCO.

Since this product showed promise of having the desired resistance to oxidation and hydrolysis, we evaluated its usability in flexible foams.

The material used in this study is a chelated stannous complex, identified as Nuocure 29S* with physical properties as given in *Table 1*.

This material showed no change in physical appearance or activity on exposure to air or atmospheric moisture. It is insoluble, but it is readily dispersed in the various components of normal foam formulations. It also imparts a faint to bright yellow color to foams depending on the concentration used. Its activity and stability were established by a number of different approaches.

Gel Time

In order to compare with established values for other catalysts, gel times were measured according to published procedures (1). Gel times were also measured at several temperatures to give an indication of the relative changes in reactivity with exotherm. Data are in *Table 2* and are shown graphically in *Figure 1*.

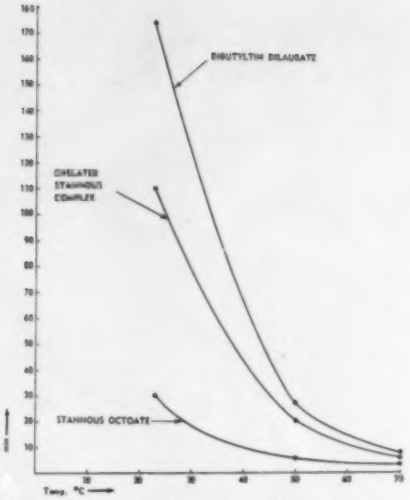


Figure 1. Gel times of the three types of catalysts at various temperatures. Relative changes in reactivity with exotherm are displayed

From these data, it is apparent that this complex is more similar to dibutyltin dilaurate and slightly more reactive. Both differ from stannous octoate in showing much greater change in reaction rates with temperature.

In practice, the changes in reactivity with temperature are important since all foaming operations are exothermic reactions. The data presented here provide only a partial answer since they are measurements of the reaction rates in a homogeneous medium. Actually in preparing a foam the reactions are not only occurring heterogeneously but the competing water reaction must also be considered.

Temperature Effects

The effect of temperature on reactivity is also important in arriving at a proposed mechanism for the catalytic activity. A simple comparison of rates at different temperatures gives a crude comparison of the activation energies. (*Table 3*)

A comparison of the gelation rates (*Table 2*) and the temperature coefficients show that the stannous octoate reaction occurs with considerably lower activation energy than those of the other two catalysts.

Solvent Influence

There is a specific solvent influence on these rates as shown in *Table 4* for stannous octoate at 70°C and 23°C.

The retarding effect of dioxane is possibly due to preferential complex formation of the Sn catalyst with dioxane which results in higher activation energy for the system.

Table 1.

Appearance	bright yellow, fine powder
% Sn (total)	29.1
% Sn (stannous)	29.0
Melting Point	225-229°C (dec.)
Specific Gravity	1.524

Table 2. Effect of Temperature on Gelation Times*

	23°C	50°C	70°C
Dibutyltin Dilaurate	173 min.	27	8
Stannous Octoate	31	5.5	3.3
Chelated Stannous Complex	110	20	5.5

* Data in Table 2 and 3 from mixtures containing 1g. catalyst, 9g. dioxane, 100g. Triol Polyether (M.W.-3000-0.1 equiv.) and 8.7g. Allied Nacconate 80 (0.1 equiv.)

* Reg. T.M. and Pat. Appl. for by Nuodex Products Co. Div. of Heyden-Newport Chemical Corporation.

Table 3. Temperature Coefficient of Gelation Rates

Ratio →	k_{50}/k_{23}	k_{70}/k_{50}
Dibutyltin Dilaurate	6.4	3.4
Stannous Octoate	5.7	1.6
Chelated Stannous Complex	5.5	3.6

The fact that addition of urethane does not materially retard the reaction lends support to the conclusion that the reaction products do not influence the reaction rate. The rates are therefore determined by the temperature and concentrations of initial reactants but catalytic activity does not change during the reaction. Changes due to change in the reaction medium (viscosity and dielectric constant) contribute to the complexity of the reaction rate and mechanism problem. Complete proof of the mechanism of catalytic activity of the tin salts has not yet been established.

Exotherms

The total exotherm, the rate of attainment of exotherm, and the gel times were determined according to previously published procedures (4). Catalysts were compared alone and in conjunction with amine catalysts to establish synergistic effects. Formulations for exotherm studies are presented in *Table 5*.

Exotherms are plotted in *Figure 2 and Figure 3* which also show the time of gelation. These curves indicate:

1) Final exotherms for the catalysts are equal.
2) Without amines total exotherm is about 2° lower than with amines.
3) Without amines the dibutyltin salt and the chelated stannous complex cause much slower and later gelation than with amines.
4) Dibutyltin dilaurate is most affected by the amine catalyst (synergism); stannous octoate is virtually unaffected.
5) With amines the behavior of the three catalysts is almost identical.

Stability of Catalyst

Storage stability of the catalyst in various premixes and foam components was determined by preparing master batches. Foams were prepared daily from these master batches and tested by standard test methods (ASTM D-1564-59T). Although stable foams could be prepared for considerable periods, the storage limit was taken as the time at which the physical properties of the foam became poorer. Deterioration usually appeared first in tensile strength and tear strength. In all cases the master batches were kept in closed containers but no special precautions were taken to protect them from air or moisture. Results are summarized in *Table 6* compared to standard tin catalysts (stannous octoate and dibutyltin dilaurate).

Table 4. Solvent Effect on Gelation Rates

	23°C	70°C
No solvent	< 2 min.	< 1 min.
Dioxane	31 min.	3.3 min.
Liquithane*	3 min.	1.5 min.

* Millmaster Chemical Corp.—A eutectic mixture of ethyl and methyl urethanes.

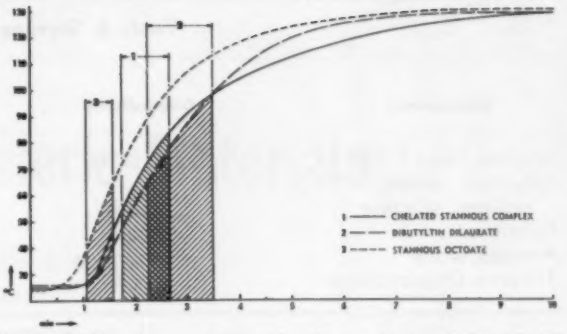


Figure 2. Exotherm curves for formulation 1 (Table 5)

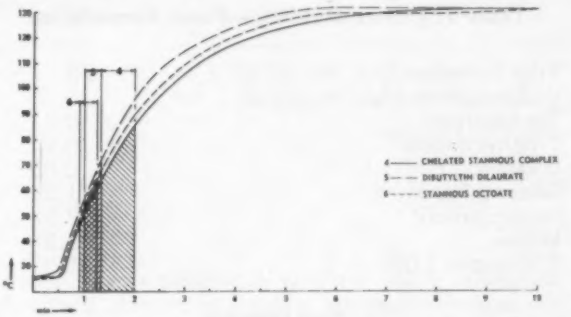


Figure 3. Exotherm curves for formulation 2 (Table 5)

This complex is then more stable in premixes than conventional catalysts. Although it is a solid and not soluble in foam components, it is readily wetted and dispersed in either silicone fluid or polyether showing only slight settling over a period of several days. A sample dispersed and partly dissolved in silicone fluid was used to make foam after three weeks storage. Neither the catalyst nor the silicone had been affected.

Formulation and average physical properties obtained are tabulated in *Table 7*.

Formulation Variables

A) The chelated stannous complex can substitute for stannous octoate (equal weight basis). Foams of equal physical properties were prepared, except that the former gave softer foams of higher resilience, as shown in *Table 8*.

B) A chelated stannous complex can be used as the sole catalyst.

In practice it is virtually essential to use the dibutyltin type of catalyst in conjunction with an amine in order to

Table 5. Formulations for Exotherm Studies

	1	2
Triol Polyether[1] 3000 M.Wt.	100.0	100.0
Silicone Fluid[2]	2.0	2.0
Tin Catalyst	0.4	0.3
Dabco[3]	0.0	0.05
Triethylamine	0.0	0.3
Fluorocarbon[4]	7.5	7.5
Water	3.5	3.5
TDI[5] Toluene Diisocyanate	45.0	45.0

[1] Union Carbide Niax Triol LG-56 was used.
[2] Union Carbide, Silicones Div., L-520 fluid was used
[3] Houdry Process Corp.
[4] GENETRON 11, General Chemical Div., Allied Chemical Corp.
[5] NACCONATE 80, National Aniline Division, Allied Chemical Corp.

Table 6. Storage Stability of Premixes

Components	Dispersibility	Storage Limit (days) Std. Catalysts	Chelated Stannous Complex
Silicone Fluid L-520	good, sl. sol.	must be kept separate	20+
Polyether, water, amines, silicone	good	< 1	7
Polyether	good	—	10
Amines, water	poor	< 1/3	9
Toluene Diisocyanate	good	must be kept separate	must be kept separate

Table 7. Premix Stability—Foam Formulation

Triol Polyether Mol. Wt. 3000[1]	75
Diol Polyether Mol. Wt. 2000[1]	25
Tin catalyst[2]	0.5
Triethyl amine	0.3
Dabco[3]	0.05
Silicone Fluid[4]	1.5
Fluorocarbon[5]	7.5
Water	3.5
TDI (index 1.05)[6]	45.0
Foam Properties	
Density, lbs./ft.[3]	1.2-1.4
Tensile Strength, psi	12-14
Elongation, %	200-300
Comp. Load, psi 25% deflection	0.25-0.30
50% deflection	0.34-0.40
Comp. Set, 90%-22 hrs., 158°F, %	<15
Tear Strength, lbs./in.	2.3-2.8

[1] Union Carbide Niax Triol LG-56 and Niax Diol PPG-2025.
[2] Stannous Octoate—Nuocure 28, Nuodex Products Co., Div. of Heyden Newport Chemical Corp. and Catalyst T-9, Metal & Thermit Corp., were used interchangeably. Dibutyltin dilaurate Catalyst T-12, Metal & Thermit Corp. and Catalyst D-22, Union Carbide Corp. were used interchangeably.
[3] Houdry Process Corp.
[4] Union Carbide Corp., Silicones Div., L-520 Fluid.
[5] GENETRON 11, Allied Chemical Corp., General Chemical Div.
[6] NACCONATE 80, Allied Chemical Corp., National Aniline Div.

Table 8. Comparison of Foams

	Free Blow		Molded (2" Thickness)	
	Chelated Stannous Complex	Stannous Octoate	Chelated Stannous Complex	Stannous Octoate
Comp. Load, 25%, psi	0.18	0.22	0.19	0.29
50%, psi	0.24	0.30	0.31	0.36
% Rebound*	50	46	43	36
Indentation Load, 2" Thickness				
25%, lbs.	—	—	15	20
65%, lbs.	—	—	36	44

* Rebound is measured on the Goodyear-Healey Rebound Pendulum (Scott Testers) with the impact angle adjusted to give 75% penetration.

get adequate gelation rates. Stannous octoate is less dependent on auxiliary catalysts but addition of amines provides better balance of the various competing reactions. Addition of amines to a chelated stannous complex has no serious effect on the overall reactivity or the foam properties. (*Figures 2-3*)

C) Foaming can be accomplished at elevated temperature.

The premixes containing this chelated stannous complex are stable and make stable foams even at temperatures of 60°C.

D) Other properties.

Many combinations of catalysts with the chelated stannous complex give good release from paper and smooth bottom surfaces similar to prepolymer foams. Standard tin catalyst one-shot foams generally do not release well.

Preliminary tests have indicated that many of these foams have good resistance to flexing (losses of less than 20% on 250,000 cycle flexing for low density foams).

This catalyst is substantially insoluble in all foam components. Therefore the degree of dispersion will have some effect on activity.

Summary

This new catalyst for urethane foams has been shown to supplement currently used tin catalysts for special purposes. It is extremely resistant to oxygen and moisture and compatible with most foam components. Premix stability is much greater than with the usual tin catalysts.

Although insoluble this catalyst is readily dispersed. The faint to bright yellow color which it imparts is not limiting in many cases.

This new material produces very soft, highly resilient foams with good release from paper.

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2. Newman, M. S.,—"Steric Effects in Org. Chem.," J. Wiley & Sons, N. Y., 218 (1956)
3. Unpublished data—National Aniline Division.
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Hardness of Polymeric Materials

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An empirical test procedure related to basic properties of plastics

The hardness of a polymeric material is usually evaluated by observing the distance of indentation and recovery which occurs when a penetrator is forced into a flat surface and then released. To compare materials, the results of such hardness measurements are then recorded according to the prescribed hardness scales (1, 2, 3). This article shows how the results of hardness tests can be interpreted in terms of the basic stress-strain behavior of the material.

The indentation of metals by penetrators of various sizes and shapes has been studied by many investigators (4, 5, 6) and the mechanism of the indentation process has been clearly defined by Tabor (7). When a ball presses onto a metal surface, the material first deforms elastically. As the load is increased, the stresses soon exceed the elastic limit and plastic flow starts. By increasing the load still further, the material directly beneath the penetrator becomes completely plastic and the metal is permanently displaced. On release of the load, there is elastic recovery and if the same load is reapplied, deformation occurs until the surfaces fit over the diameter of the original impression. A similar approach has been used to study the hardness of polymers, although in parts the theory had to be modified to account for differences in the mechanical behavior.

This article is divided into two parts. First, the indentation process is considered when large loads are placed on the penetrator and the material beneath the indenter becomes permanently displaced. Second, the recovery process which occurs immediately after the load is released is defined and analyzed in terms of the elastic concepts developed by Hertz (8).

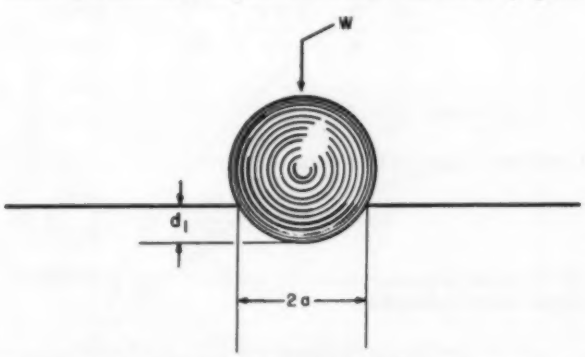


Figure 1. Indentation of a material

Discussion, Theory and Experimental Verification

Indentation on Application of Large Loads—Consider first the case when a relatively large load, W, is placed on the indenter and the material beneath the indenter is permanently deformed. From previous results with metals, the following relation has been verified

$$\frac{W}{A} = K\sigma_o \qquad (1)$$

where A is the projected area of contact, σ_o is the yield stress of the material and K is a constant. From theoretical considerations, K has been shown to be 2.57 (6). According to *Figure 1*, the assumption is made that the shape of the indentation is a spherical segment, and it follows that the projected area of contact can be calculated from the equation

$$A = \pi a^2 = \pi (Dd_1 - d_1^2) \qquad (2)$$

where D is the diameter of the penetrator and d_1 is the distance of indentation. If the distance of indentation is very small compared to the diameter of the indenter, $Dd_1 >> d_1^2$, then,

$$a^2 = Dd_1 \qquad (3)$$

If on the release of the load, the projected area of contact remains constant, the validity of Equation (3) may be checked by measurement of the distance of indentation, d_1, and the diameter of the projected circle of contact, 2a. The results of indentation tests using injection molded bars of polyoxymethylene resin are given in *Table I*. The calculated projected diameter of contact was in close agreement with the observed value and any deviations between both values can be attributed to experimental error.

Combining Equations (1) and (3) gives

$$d_1 = \frac{0.124}{D\sigma_o} W \qquad (4)$$

* Now Assistant Professor of Chemical Engineering, University of Illinois.

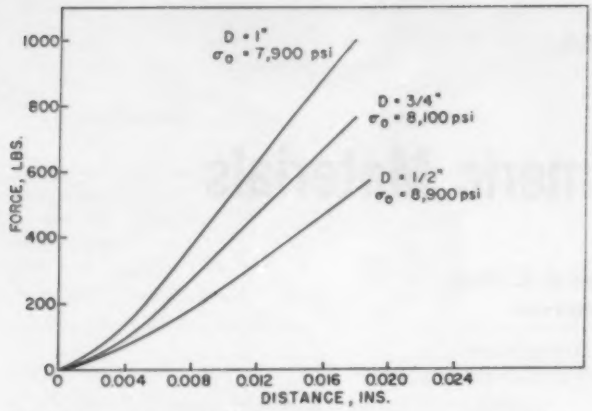


Figure 2. Indentation of sphere into polyoxymethylene using an "Instron" testing machine

Table 1. Prediction of the Diameter of Indentation

Diameter of Penetrator, D	Depth of Indentation, d_1	Calculated Diameter of Contact $2\sqrt{Dd_1}$	Observed Diameter of Contact
0.50 ins.	0.0038	0.082	0.087
0.50 ins.	0.0060	0.11	0.10
0.50 ins.	0.0087	0.13	0.13

Table 2. Comparison of Yield Stress from Hardness and Tension Tests

Material	Yield Stress, psi Hardness Test	Yield Stress, psi ASTM Tension Test
Styrene-Butadiene-Acrylonitrile Terpolymer	4,860	4,600
Polyoxymethylene	8,300	9,000
Polypropylene	3,600	4,500
Polyvinyl Chloride (Unplasticized)	8,500	7,900
66 Nylon (Dry)	10,600	11,900

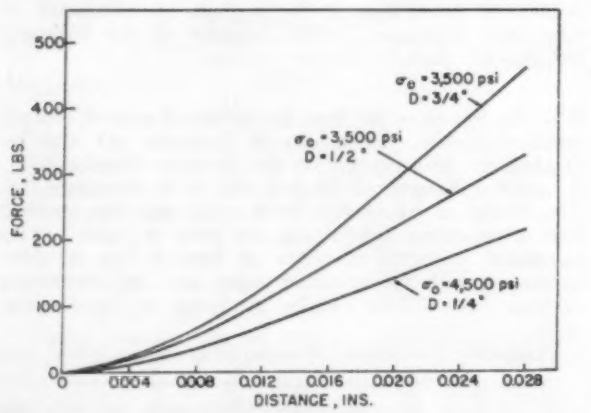


Figure 3. Indentation of sphere into polypropylene using an "Instron" testing machine

According to Equation (4), a plot of the load against the deformation on linear graph paper should give a straight line. This applies only to relatively large loads when the material directly beneath the indenter has been permanently deformed.

To check the applicability of this analysis, a series of experiments were conducted on an "Instron" Testing Machine and on a Rockwell Hardness Tester. Throughout, the system studied was a ball indenting a flat slab of material ¼ inch thick. All of the experimental measurements with the hardness tester were made 30 seconds after the load was applied and 30 seconds after the load was released. The time taken for the hardness tests was of the some order of magnitude as the duration of the tension tests.

Figures 2 and 3 show the force-distance of indentation curves which were obtained when metal spheres of various diameters indented a plane slab of a polymeric material. The curves show that when the force exceeded 100 lbs. a linear relation exists. According to the theory, the yield stress of the material can be calculated from the slope of the line and the results show that such a yield stress increases as the diameter of the indenter decreases. Since the material beneath the indenter is permanently deformed, the data indicate that the amount of "working" depends on the radius of curvature of the spherical indenter.

When large indenters are used, the yield stress calculated from hardness tests should be similar to the yield stress obtained from a simple tension test. The results of experiments with the Rockwell hardness tester using a ¾ inch diameter penetrator are shown in *Table 2*. Good agreement was obtained between test results from the tension and the hardness tests.

Recovery on Release of the Load—When the load is removed from the indenter there is partial recovery. Since, as shown in *Table 1*, the projected area of contact remains constant, the recovery mechanism shown in *Figure 4* is assumed.

According to the Hertz theory (based on elasticity theory),

$$a = 1.11\left[\frac{W}{2}\frac{r_1 r_2}{r_2 - r_1}\left(\frac{1}{E_1} + \frac{1}{E_2}\right)\right]^{1/3} \qquad (5)$$

Since in all experiments a metal indenter was used, Equation (5) is simplified by assuming that $E_1 >> E_2$. Therefore

$$a = 1.1\left[\frac{W}{2E}\frac{r_1 r_2}{r_2 - r_1}\right]^{1/3} \qquad (6)$$

According to Equation (2), if the distance of indentation is small when compared to the diameter of the indenter, then

$$A = \pi a^2 = 2\pi d_1 r_1 = 2\pi d_2 r_2 \qquad (7)$$

Rearranging Equations (6) and (7) gives

$$\frac{1}{r_1} - \frac{1}{r_2} = \left(\frac{1.11}{a}\right)^3 \frac{W}{2E} \qquad (8)$$

$$\frac{1}{r_1} - \frac{1}{r_2} = \frac{2\pi}{A}(d_1 - d_2) \qquad (9)$$

Combining Equations (8) and (9) gives,

$$d_1 - d_2 = 0.11\frac{AW}{a^3 E} \qquad (10)$$

However, $A = \pi a^2$ and $a = (d_1 D_1)^{1/2}$. By substitution Equation (10) becomes

$$d_1 - d_2 = 0.346\frac{W}{E(d_1 D_1)^{1/2}} \qquad (11)$$

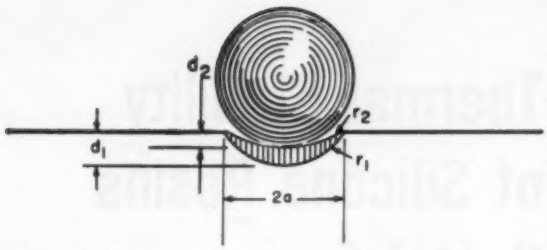


Figure 4. Recovery on release of load

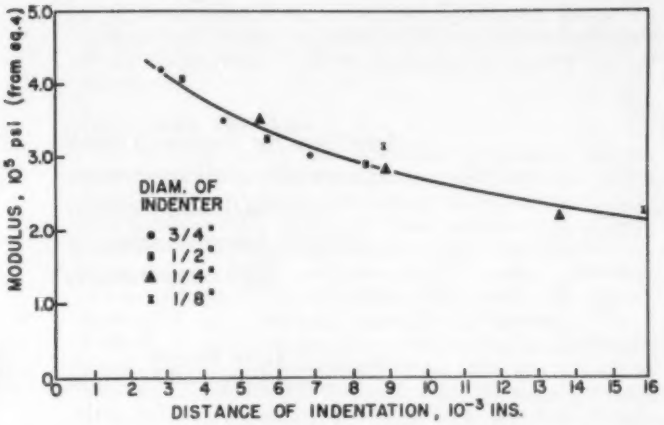


Figure 5. Decrease of modulus with increasing distance of indentation for polyoxymethylene

Since the initial distance of indentation, d_1, and the distance of recovery, $d_1 - d_2$, are readily measured with a standard hardness tester, a modulus can be calculated by substitution into Equation (11).

In *Figures 5 and 6* are the results of recovery experiments with polyoxymethylene and 66 nylon (2.6% moisture content) which were obtained on a Rockwell tester using penetrators of various diameters. The results show that the modulus calculated from hardness measurements decreases with increasing distance of indentation. This is to be expected since the strain is increased as the indentation is deepened. By assuming 3×10^{-3} ins. of indentation corresponds to 1% strain in a tension test, the stress can be calculated by multiplying the strain by corresponding modulus obtained from the hardness tests. In this manner, the stress-strain curves can be constructed from hardness measurements. In *Figure 7*, the stress-strain curves from hardness tests are compared with the tension curves. A close similarity is evident.

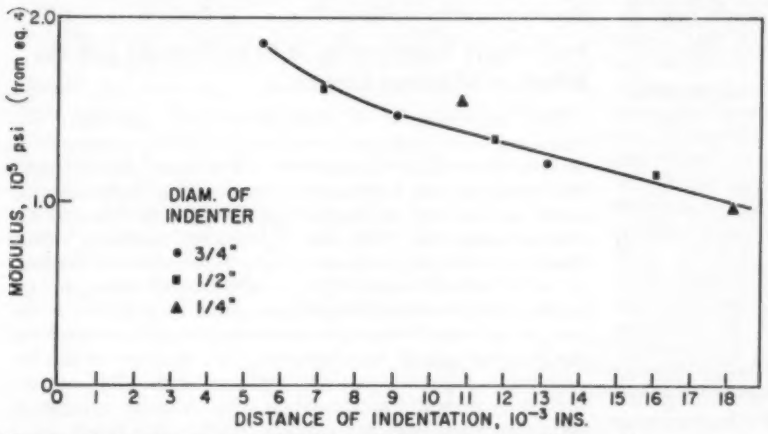
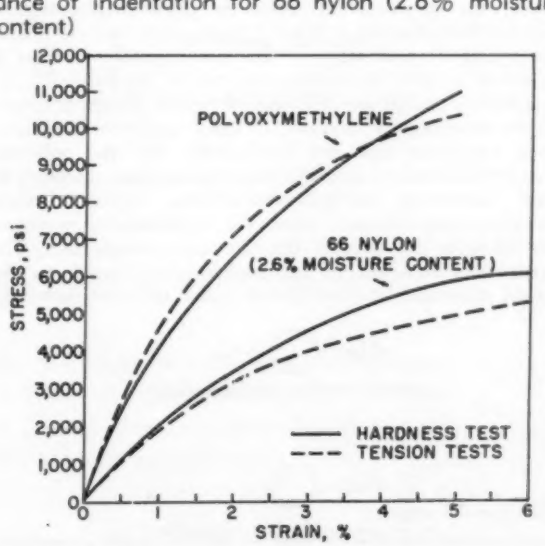


Figure 6. Decrease of modulus with increasing distance of indentation for 66 nylon (2.6% moisture content)



Nomenclature

W	Load, lb
A	Projected area of contact, in.² (a = radius, in.)
K	Constant = 2.57
σ_o	Yield stress, lb/in.²
d_1	Distance of indentation, in.
$d_1 - d_2$	Distance of recovery, in.
D	Diameter of penetrator, in.
r_1	Radius of penetrator, in.
r_2	Radius of indentation after recovery, in.
E_1	Modulus of metal, lb/in.²
E_2,E	Modulus of polymer, lb/in.²

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Figure 7. Comparison of stress-strain curves from tension and hardness tests

Adapted from a paper presented at the 17th Annual Technical Conference of the Society of Plastics Engineers, Washington, D. C., January 24-27, 1961.

Thermal Stability of Silicone Resins Containing p-Phenylenedisilanes

A method for screening small quantities of silicone resins for ultimate flexural strength determinations at high temperatures

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In the search for polymers stable at temperature approaching 1000°F, new silicon-containing materials continue to receive attention. Commercially available silicone resins may be cured to solid materials that exhibit a high degree of chemical stability at elevated temperature, but tend to lose structural rigidity at those temperatures. Their thermal instability, both with regard to loss of strength and chemical decomposition, may be related to a variety of factors. A purely thermal instability of siloxanes may result from the rearrangement of siloxane linkages, a change that occurs above 660°F (4). Also, uncondensed functionality in the form of silanol groups may either promote such rearrangements or undergo condensation to form additional polymeric linkages. Thermal-oxidative instability is most frequently described in the chemical literature. This type of decomposition, which may become significant at temperatures as low as 480°F, depending on the organic group present, involves the oxidative cleavage of carbon-carbon or carbon-silicon bonds in the polymer (3). The formation of many small cyclic structures during the hydrolysis of trifunctional silane monomers may yield a weaker finished plastic material. These cyclics reduce the effective functionality of the monomer below an optimum value, thereby decreasing the cross-linking potential of the polymer. The resulting material would be expected to have some properties similar to thermoplastic polymers. The size and space relationships of substituents on the polymer chain, the rigidity of the polymer chain itself, and the probability of interchain bonding can have a profound effect on the susceptibility of the polymer to temperature.

Although there are numerous patents and publications in the literature regarding the synthesis of silane monomers with the structure, $X_3SiRSiX_3$, where X is a functional group capable of undergoing hydrolysis and condensation to form siloxanes and R is an arylene or an alkylene group, little attention has been given to their use in polymer preparation. The use of monomers of this type in polymeric compositions promises a means of approaching several of the basic causes of thermal instability in silicone resins: Rearrangements, the formation of small cyclic structures during polymerization, lack of control of the effective functionality of resin components, and the lack of rigidity of the polymer chain.

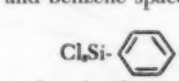
This article describes exploratory work relating to the incorporation of arylenedisilane monomers in silicone resins. The purpose of the work is not to establish formulations, but rather to determine if the modification of conventional silane mixtures, which may be used to prepare resins, with the experimental monomers produces materials with the improved thermal properties that might be predicted.

The ultimate flexural strengths of glass fabric laminates prepared from the experimental resins were used as criteria of thermal stability. This procedure was adopted because it gave information relating to thermally induced changes in the rigidity of the polymer. Because of the limited amount of each experimental resin that was available, the customary procedure of preparing 12 x 12 in. square, ¼ in. thick laminates was abandoned in favor of the use of 6-ply, 4 x 4 in. square laminates. This procedure is described in detail in the experimental section.

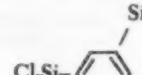
Preliminary Examination of Resin Systems and the Selection of Spacer Groups

The incorporation of phenylenedisilane monomers into resins implies a large number of compositional parameters to be defined. In early experiments it was found that attempts to hydrolyze pure monomers gave insoluble materials that could not be used to impregnate glass fabric. Therefore it was necessary to dilute the experimental monomers with other resin forming monomers such as phenyltrichlorosilane or methyltrichlorosilane. Also, a difunctional silane, for example dichloromethylphenylsilane, could be included in the mixture to be hydrolyzed. A second important parameter was the functionality of the monomer. One or more of the hydrolyzable halogens may be replaced with alkyl or aryl groups by means of condensation with Grignard reagents to form monomers with any average functionality below six.

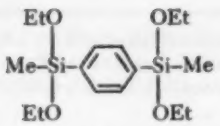
From preliminary qualitative examination of a system containing the experimental monomer phenyldichlorosilyltrichlorosilylbenzene, the following generalizations were made: The average functionality of the experimental monomer is important in determining the properties of the finished polymer; methyl groups are preferred to phenyl groups in reducing the functionality; addition of small quantities of difunctional monomers does not significantly alter the polymer; phenyltrichlorosilane as a diluent gives superior materials to those containing methyltrichlorosilane; highest flexural strengths were obtained when the experimental monomer was 35 mole per cent of the monomer composition. The experiments reported in this article were based on the phenyl ether and benzene spacer in five different materials:



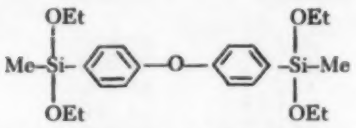
p-phenylenebis(trichlorosilane)



m-phenylenebis(trichlorosilane)



p-phenylenebis(diethoxymethylsilane)



4,4'-bis(diethoxymethylsilylphenyl) ether

mixed m- and p-phenylenebis(trichlorosilane)

Resins from each of these materials were prepared from mixtures of monomers containing 35 mole per cent methyltrichlorosilane or methyltriethoxysilane unless otherwise specified. The hydrolyzing and laminating procedures are outlined in the experimental section. Where the functionality was varied, the monomer was reacted with the calculated amount of methylmagnesium bromide to yield the desired monomer prior to mixture with the monosilane.

The data in *Table 1* reveal that mixed m- and p-phenylenedisilanes give stronger laminates at 500° than either the meta or para isomer alone. The same is not true for the room temperature tests, although the laminate prepared from the meta isomer is significantly weaker than either of the other two.

It is obvious from the data in *Table 1* that the average functionality of the experimental monomer is important in determining strength, even in determining whether or not a laminate can be prepared from a given monomer composition. It is interesting that the results differ when p-phenylenebis(diethoxymethylsilane) is hydrolyzed and when p-phenylelebis(trichlorosilane) is first treated with 2 moles of methylmagnesium bromide and then hydrolyzed. Either the positioning of the methyl groups or the incomplete hydrolysis of the silicon-attached alkoxy groups could account for this difference.

Fabrication Variables

In order to verify that fabrication procedures for the preparation of conventional laminates could be used in this study of the experimental monomers, several of the fabrication variables were examined. These include resin pickup, catalyst concentration, and laminating press temperature. These three variables were shown in an earlier publication (2) to be important as fabrication variables in determining the strength in conventional materials. The results, shown in *Tables 2, 3, and 4*, are consistent with results that can be obtained from more conventional resins. The resins used in these experiments were prepared from 35 mole per cent methyltrichlorosilane mixed with 65 mole per cent phenyldichlorosilyltrichlorosilylbenzene that had been treated with sufficient methylmagnesium bromide to yield a monomer with an average functionality of 4.

Within the limits of the experiments and at the 95 per cent confidence level an optimum range of resin pickup was found for the samples tested at 500°F. However, for the room temperature tests no significant differences were detected provided the resin pickup exceeded a certain minimum. Differences obtained by increasing the press temperature during lamination were not large; the only meaningful changes in strength were found when the temperature was increased to 550°F. Throughout the range of catalyst concentrations examined, no significant effects were found.

Composition Variables

Each of the composition variables, concentration and identity of the silane diluent and average functionality of the experimental monomer, was examined in order to approximate the optimum composition for the experimental resins. In additional exploratory experiments on systems containing phenyldichlorosilyltrichlorosilylbenzene it was shown that the optimum average functionality for this monomer was in the neighborhood of four and that the best strengths could be obtained if the experimental monomer were diluted

Table 1. Flexural Strengths of Laminates Prepared from Different Experimental Monomers

	Experimental Monomer	Average Functionality	Ultimate Flexural Strength Lb./Sq. In. Room Temp.	500°F
1.	Mixed m- and p-phenylenebis(trichlorosilane)	5	resin gelled	
		4	30,700	15,300
		3	43,300	14,200
2.	p-Phenylenebis(trichlorosilane)	5	resin gelled	
		4	laminate delaminated	
		3	48,700	11,600
3.	m-Phenylenebis(trichlorosilane)	5	resin gelled	
		4	12,200	5,200
		3	29,600	10,900
4.	p-Phenylenebis(diethoxymethylsilane)	4	14,400	11,900
5.	(4) with no $Me_2Si(OEt)_2$	4	12,100	9,800
6.	Bis-p-(diethoxymethylsilyl)-phenyl ether	4	36,300	18,100
7.	(6) with no $MeSi(OEt)_3$	4	30,100	16,700

Strength values are the average of 3 determinations

Table 2. Flexural Strength vs Resin Pickup for Laminates Prepared from Phenyldichlorosilyl-Trichlorosilyl-Benzene

Laminate No.	Resin Pickup	Flexural Strength, Lb./Sq. In.	
		Room Temp.	500°F
1	12.5	17,500	5,300
2	18.0	28,600	12,000
3	21.5	31,100	12,600
4	28.2	29,200	11,300
5	32.0	28,400	7,700
6	37.5	30,000	7,200

Strength values are the average of 3 determinations

Table 3. Flexural Strength vs Laminating Temperature for Laminates Prepared from Phenyldichlorosilyl-Trichlorosilyl-Benzene

Laminate No.	Laminating Temperature, °F	Flexural Strength, Lb./Sq. In.	
		Room Temp.	500°F
1	390	29,800	11,900
2	430	29,800	10,800
3	470	31,000	9,300
4	510	26,700	9,600
5	550	22,300	7,000

Strength values are the average of 3 determinations

Table 4. Flexural Strength vs Catalyst Concentration for Laminates Prepared from Phenyldichlorosilyl-Trichlorosilyl-Benzene

Laminate No.	Catalyst Concentration	Flexural Strength, Lb./Sq. In.	
		Room Temp.	500°F
1	0.0	33,600	16,900
2	0.05	34,400	18,200
3	0.1	32,600	15,200
4	0.2	35,600	17,700
5	0.4	37,400	17,800

Strength values are the average of 3 determinations

with 80 mole per cent or more phenyltrichlorosilane. Very poor materials were obtained when the functionability was decreased to 3.5 or increased to 5.0. A satisfactory laminate could not be obtained from a composition based entirely on phenyltrichlorosilane.

In the final evaluation tests, higher temperatures and longer exposure at high temperatures were used in determining thermal stability. One group of materials was studied after exposure for one-half hour at 500°, 575°, 650°, 725°, and 800°. Another group was tested after one-half, 100, and 200 hours at 500°, 575°, and 650°F. The results are summarized in *Tables 5-11*.

Tables 6 and 7 indicate that the optimum monomer functionality is very close to four. Attempts to prepare resins from monomers with an average functionality of 3.5 gave materials that formed laminates that were too poor to be tested. However, the difference between these results and those that were obtained when phenylenebis(trichlorosilanes) with functionality reduced entirely with MeMgBr (see *Table 1*), clearly suggests that the optimum functionality must be determined individually for each monomer system.

It is also clear from *Tables 8 and 9* that only small amounts of the disilane monomers are required to introduce enhanced rigidity in silicone resins containing phenyltrichlorosilane. At the concentrations tested the strengths increased significantly as the experimental monomer concentration was decreased, but strengths were greatly decreased if the experimental monomer was omitted from the composition. The same effect was not observed when the diluent was methyltrichlorosilane.

When methyltrichlorosilane is the only diluent there is little difference observed between strengths at room temperature and 500°F although the room temperature strengths were not particularly high. Good strength retention and high room temperature strengths were not obtained from mixtures of phenyltrichlorosilane and methyltrichlorosilane as demonstrated in *Table 10*. The main effect seems to be a significant reduction in room temperature strength even when small quantities of methyltrichlorosilane were added.

Outstanding among these results was that above 500°F

Table 5. Flexural Strengths of Experimental Laminates: Tests to 200 Hr. at 650°F

Test Temp. (°F)	Aging Time (Hr.)	Resin Prepared From $PhSiCl_2C_6H_4SiCl_3$ (functionality reduced to 4 with MeMgBr) mixed with 80 mole per cent		Bis-p-(methyldiethoxysilyl)phenyl ether (Lb./Sq. In.)	Commercial Laminating Resin (Lb./Sq. In.)
		$MeSiCl_3$ (Lb./Sq. In.)	$PhSiCl_3$ (Lb./Sq. In.)		
Room temp.		21,500 (12)	29,800 (10)	28,600 (6)	39,100 (4)
500	1/2	17,900 (5)	17,200 (6)	16,200 (4)	17,000 (2)
	100	16,200 (2)	16,900 (2)	16,100 (2)	13,200 (1)
	200	16,700 (2)	18,500 (2)	14,000 (2)	14,700 (1)
575	1/2	19,500 (3)	17,500 (4)	15,800 (2)	13,800 (4)
	100	19,700 (2)	15,100 (2)	15,600 (2)	15,500 (1)
	200	20,400 (2)	17,500 (2)	15,500 (2)	14,400 (1)
650	1/2	16,400 (2)	15,300 (2)	14,000 (1)	12,300 (3)
	100	17,800 (1)	14,800 (1)	15,000 (1)	11,700 (1)
	200	17,200 (1)	12,400 (1)	13,600 (1)	12,100 (1)

Average values are shown for results of tests on 6-ply laminates prepared from three experimental resins: The monomeric composition of each resin is indicated. All laminates were tested after aging ½, 100, and 200 hr. at the test temperature. Strength values are the average of the number of determinations shown in parentheses.

Table 6. Flexural Strengths of Experimental Laminates Based on Phenyltrichlorosilane: The Effect of Functionality

Test Temp. (°F)	Average Functionality 4.0 (Lb./Sq. In.)	4.25 (Lb./Sq. In.)	4.5 (Lb./Sq. In.)	5.0 (Lb./Sq. In.)
Room Temp.	29,800 (10)	30,800 (3)	25,300 (3)	15,000 (3)
500	17,200 (6)	16,600 (4)		
575	17,500 (4)	19,200 (2)		
650	15,400 (2)	18,100 (1)		
725	18,900 (1)	18,800 (1)		
800	17,600 (1)	17,700 (1)		

Average values are shown for results of tests on 6-ply laminates prepared from resins containing 80 mole per cent $PhSiCl_3$ and 20 mole per cent $PhSiCl_2C_6H_4SiCl_2$ reduced to an average functionality of 4.0, 4.25, 4.5 and 5.0 with MeMgBr. All laminates were tested after aging ½ hr. at the test temperature. Strength values are the average of the number of determinations shown in parentheses.

the test method could not detect significant changes in the strength of the experimental laminates under any of the test conditions. Changes at these temperatures were easily detected in the commercial materials.

For purposes of comparison, two series of 12-ply laminates were prepared and tested. The results are shown in *Table 11*. The results for the commercial resin at elevated temperatures agree well with those reported by Boller and Kimball (1). At temperatures above 500°F the experimental laminates gave ultimate flexural strengths about 50 per cent greater.

Experimental Procedure

Preparation of resins: In preparing resins from the experimental chlorosilane monomers, phenyldichlorosilyltrichlorosilylbenzene, p-phenylenebis(trichlorosilane), m-phenylenebis(trichlorosilane), or isomeric phenylenebis(trichlorosilanes), the silane was first treated with methylmagnesium bromide to reduce the average functionality of the monomer to the required value. The product, mixed with the specified amount of phenyl- or methyltrichlorosilane, was hydrolyzed in an organic solvent-water mixture. The alkoxysilane monomers were hydrolyzed directly in a mixture containing organic solvents and dilute hydrochloric acid.

Typical preparation of a resin from a chlorosilane: In a 1 liter flask were placed 24.9 g. phenyldichlorosilyl-trichlorosilyl-benzene and 80 g. toluene. While this mixture was stirred and cooled in a water bath to maintain the temperature at 25°C, 21.5 ml. 3 M methylmagnesium bromide in diethylether was added dropwise. When the addition was complete, the product was filtered and the salt cake washed with 80 g. toluene. The washings were combined with the filtrate, and 34.5 g. phenyltrichlorosilane was added. This silane mixture was added dropwise to a 2 liter flask containing a stirred mixture of 40 g. toluene, 120 g. Ansul Ether 222, 50 g. isopropyl alcohol, and 142 g. water. External cooling was required to maintain the temperature at 25°C. When the addition was complete, the mixture was stirred an additional hour at room temperature. Xylene (100 ml.) was added, and then the organic phase was separated, washed three times with 100 ml. portions of each of the following: Distilled water, 5 per cent $NaHCO_3$, and distilled water. The resulting resin solution was filtered and concentrated by distillation to about 50 per cent solids content.

Typical preparation of a resin from an alkoxysilane: Bis-p-(diethoxymethylsilyl)phenyl ether, 75.5 g., dissolved in 150 g. toluene, was added dropwise to a stirred mixture containing 37 g. toluene, 113 g. Ansul Ether 222, 125 g. isopropyl alcohol, 136 g. water, and 44 g. 20 per cent aqueous HCl. After the mixture was stirred 1 hr., the organic phase was separated and diluted with 50 ml. of both Ansul Ether 222 and xylene. The resin solution was washed in the same manner as in the chlorosilane procedure, filtered, and concentrated by distillation at reduced pressure to about 30 per cent solids content. During the washing, addition of small quantities of isopropyl alcohol was required to aid in the separation of phases and prevent the precipitation of solids.

Preparation and testing of laminates: Laminates were prepared with 6 plies of 181 style heat-cleaned glass fabric which was first water-rinsed and air-dried. In laying up the laminates, alternate plies were rotated 90°. Most of the specimens were 4 x 4 in. square, the resins were catalyzed by 0.1 to 0.2 per cent triethanolamine (based on resin solids), and the impregnated fabric was precured 5 min. at 230°F.

Table 7. Flexural Strengths of Experimental Laminates Based on Methyltrichlorosilane: The Effect of Functionality

Test Temp. (°F)	Average Functionality 4.0 (Lb./Sq. In.)	4.25 (Lb./Sq. In.)	4.5 (Lb./Sq. In.)	5.0 (Lb./Sq. In.)
Room Temp.	21,700 (12)	15,900 (4)	10,400 (3)	7,700 (3)
500	17,900 (5)			
575	19,500 (3)			
650	16,400 (2)			
725	21,100 (1)			

Average values are shown for results of tests on 6-ply laminates prepared from resins containing 80 mole per cent $MeSiCl_3$ and 20 mole per cent $PhSiCl_2C_6H_4SiCl_2$ reduced to an average functionality of 4.0, 4.25, 4.5 and 5.0 with MeMgBr. All laminates were tested after aging ½ hr. at the test temperature. Strength values are the average of the number of determinations shown in parentheses.

Table 8. Flexural Strengths of Experimental Laminates Based on Phenyltrichlorosilane: The Effect of Concentration

Test Temp. (°F)	Mole Per Cent $PhSiCl_3$ in Resins 80 (Lb./Sq. In.)	85 (Lb./Sq. In.)	90 (Lb./Sq. In.)
Room Temp.	29,800 (10)	33,400 (3)	39,300 (3)
500	17,200 (6)	19,100 (4)	22,900 (4)
575	17,500 (4)	20,500 (2)	19,200 (2)
650	15,300 (2)	21,200 (1)	21,400 (1)
725	18,900 (1)	21,400 (1)	19,500 (1)
800	17,600 (1)	20,400 (1)	18,000 (1)

Average values are shown for results of tests on 6-ply laminates prepared from resins containing $PhSiCl_2C_6H_4SiCl_2$ reduced to an average functionality of 4.0 with MeMgBr and 80, 85 and 90 mole per cent $PhSiCl_3$. All laminates were tested after aging ½ hr. at the test temperature. Strength values are the average of the number of determinations shown in parentheses.

Table 9. Flexural Strengths of Experimental Laminates Based on Methyltrichlorosilane: The Effect of Concentration

Test Temp. (°F)	Mole Per Cent $MeSiCl_3$ in Resins 80 (Lb./Sq. In.	85 (Lb./Sq. In.)	90 (Lb./Sq. In.)
Room Temp.	21,700 (12)	18,200 (3)	18,200 (3)
500	17,900 (5)		18,000 (1)
575	19,500 (3)		18,400 (1)
650	16,400 (2)		17,500 (1)
725	21,100 (1)		20,200 (1)

Average values are shown for results of tests on 6-ply laminates prepared from resins containing $PhSiCl_2C_6H_4SiCl_2$ reduced to an average functionality of 4.0 with MeMgBr and 80, 85 and 90 mole per cent $MeSiCl_3$. All laminates were tested after aging ½ hr. at the test temperature. Strength values are the average of the number of determinations shown in parentheses.

Unless otherwise specified, all samples were laminated at 30 lb./sq.in. and given a stepwise postcure with a final temperature of 500°F for 60 hr.

For the impregnation step, the dissolved solids content of each resin batch was determined experimentally. An entire weighed sample of the resin solution containing the required resin solids was used to impregnate a single piece of glass cloth cut to size for the layup. When a suitable resin content and resin flow were not obtained for the first laminate from a resin batch, changes were made in the procedure to bring subsequent values into the required range. This technique permitted reproducible and controlled results to be obtained on resin pickup.

Each laminate (about 1/16 in. thick) was cut into eight test pieces, ¾ in. by 2 in. Flexural strengths were determined from each side of the laminate, and the value selected was an average of the two strengths.

Flexural strength tests were carried out on the approximately 2 in. by 3/4 in. by 1/16 in. specimens according to L-P-406b, Test No. 1031. All testing conditions, including the loading rate and test piece span, were met except that only a ½ in. overhang was possible. Ultimate flexural strengths were determined with a Baldwin-Southward Universal Testing Machine with a Dillon Mechanical Gage (0-500 lb. range—1 per cent scale accuracy) mounted on the loading nose shaft of the testing machine.

Table 10. Flexural Strengths of Experimental Laminates Based on Methyltrichlorosilane and Phenyltrichlorosilane

Mole Per Cent $PhSiCl_3$	Mole Per Cent $MeSiCl_3$	Test Temperature: Room Temperature (Lb./Sq. In.)	500°F (Lb./Sq. In.)
90	0	39,300 (3)	22,900 (4)
72	18	25,700 (3)	18,500 (3)
54	36	21,800 (4)	16,700 (4)
36	54	18,900 (4)	17,000 (4)
18	72	17,800 (4)	16,100 (4)
0	90	18,200 (3)	18,000 (1)

Average values are shown for results of tests on 6-ply laminates prepared from resins containing 10 mole per cent $PhSiCl_2C_6H_4SiCl_2$ reduced to an average functionality of 4.0 with MeMgBr and various amounts of $MeSiCl_3$ and $PhSiCl_3$. All laminates were tested after aging ½ hr. at the test temperature. Strength values are the average of the number of determinations shown in parentheses.

Table 11. Flexural Strengths of Experimental Laminates: 12-Ply Laminates Up to 800°F

Test Temp. (°F)	10 Mole % $PhSiCl_2C_6H_4SiCl_2$ (Av. Funct. 4.0) 90 mole % $PhSiCl_3$ (Lb./Sq. In.)	Commercial Laminating Resin (Lb./Sq. In.)
Room Temp.	25,800 (1)	30,900 (3)
500	15,600 (2)	13,500 (2)
575	16,500 (2)	11,700 (1)
650	15,400 (2)	9,900 (1)
725	15,200 (2)	10,100 (2)
800	15,900 (2)	10,600 (2)

Average values are shown for the results of the test on 12-ply laminates prepared from the indicated resin compositions. All laminates were tested after aging ½ hr. at the test temperature. Strength values are the average of the number of determinations shown in parentheses.

On the basis of strength values obtained at room temperature and at 500°F for series of laminates obtained from the same resin batch, an error term was calculated by standard statistical methods. Calculations were based on the log of the strength values because the variation in measurement increased with increasing magnitude of measurement.

Conclusions

A method for the screening small quantities of silicone resins for ultimate flexural strength at elevated temperatures is described. On the basis of this method it is shown that the incorporation of phenylenedisilane monomers in silicone resins compositions significantly improves the elevated temperature stability of these resins.

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Comparison of Spiral-Cavity Mold Flow with Laboratory Scale Flow Tests on Thermoplastics

J. J. Gouza and G. G. Freygang

Rohm & Haas Company

Spiral-cavity molds have been used for studying the flow of thermoplastics during injection molding (1, 2, 3, 4, and 5). Such tests essentially duplicate production molding conditions. They are costly to run because they require a large amount of material and time, plus the use of an expensive injection molding machine. There is a need for laboratory scale flow test methods which correlate with production molding. A number of laboratory methods of measuring flow have been developed (6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, and 18). In general, these methods are capable of characterizing different plastic materials and distinguishing between grades of the same basic material. Sometimes it appears that the differentiations do not correlate with practical observations on injection molding.

Since the spiral-cavity mold flow test may be considered a good reference for evaluating other test methods, it was used to measure the flow of eleven thermoplastics under practical injection molding conditions. The data thus obtained are correlated in this study with measurements made in four laboratory scale testers. The tests selected were the ASTM D569-59 method of test for "Measuring the Flow Properties of Thermoplastic Molding Materials" (19), a modified ASTM D1238-57T, "Tentative Method of Test for Measuring Flow Rates of Thermoplastics by Extrusion Plastometer" (20), a Rohm & Haas Company design of extrusion plastometer and the C. W. Brabender "plastograph" (21, 22, & 23).

Test Procedures

Spiral-Cavity Mold Test—The spiral-cavity mold used in these tests has a 0.100" x 0.625" x 60" long channel calibrated in ½" lengths. This mold was installed in a 4-ounce (model no. L-2-4) Lester injection molding machine.

Using the maximum injection pressure (20,000 psi), a selected time cycle and constant mold and cylinder temperature, the feed of the material to the cylinder was adjusted until the plunger movement stopped at a predetermined point before it completed its full forward stroke thus indicating that the flow into the mold had ceased. The cylinder temperatures selected covered an 80°F range for each material. The mold temperatures were 150°F and 180°F and the time cycle (not the same for all materials) was one producing satisfactory parts. When the equilibrium conditions were established the lengths of 25 parts were recorded for each cylinder and mold temperature. *Figure 1* shows a 42" long styron 666 spiral produced.

MATERIALS USED

THE MATERIALS INTERCOMPARED IN THIS INVESTIGATION WERE TYPICAL EXAMPLES OF COMMERCIALLY AVAILABLE MOLDING POWDERS. THEY INCLUDED ACRYLICS (PLEXIGLAS V-100, PLEXIGLAS VM-100, PLEXIGLAS VS-100, PLEXIGLAS V [TYPE 607], LUCITE 140, LUCITE 130, LUCITE 129), MODIFIED ACRYLICS (IMPLEX A), POLYSTYRENE (STYRON 666, STYRON 700), AND CELLULOSE ACETATE-BUTYRATE (TENITE 460A H-3). THE MOLDING POWDER PELLETS WERE INFRA-RED DRIED FOR 45 MINUTES AND HOPPER DRIED AT 190°F (88°C) PRIOR TO TESTING.

ASTM D569-59 Flow Temperature Test—The Rossi-Peakes flow tester is a constant force extrusion type unit in which the extent of flow in a tubular orifice is measured at a standard time interval after application of the pressure.

The ⅜" diameter, ⅜" long premolded test specimen was inserted into the hot charge chamber and the pressure (1500 PSI) applied immediately. The distance of flow of the material into the ⅛" diameter, 1½" long orifice in the split cone was measured at the end of two minutes. Each material was tested at five temperatures selected to overlap 1" of flow. The flow distance was plotted against temperature on semi-logarithmic paper. The temperature at which the flow was exactly 1.0" was read from the graph and recorded as the ASTM flow temperature.

Figure 1. Spiral molding of styron 666

R & H Co. Extrusion Test—This extrusion plastometer is a type of pressure viscometer with a capillary orifice (0.100" diameter, 0.380" long). The plastic material is forced around a flow guide and through the orifice by a piston which is moved at a constant rate. The force required to move the piston is measured and the flow rate is calculated from the rate of piston motion. The piston motion and force measurements are obtained from a universal testing machine.

A premolded plug (1" diameter, 1½" long) of the thermoplastic material was placed in the plastometer and heated at a constant rate of temperature increase of 5°C per minute under a pressure of 10,000 PSI. After the material began to extrude, the piston was advanced at constant rate (0.02" per minute). The pressure at which the material extruded at the selected constant volume rate over the temperature range was recorded. The temperature extrusion curve was obtained by plotting pressure versus temperature on semi-logarithmic paper. From these curves the apparent viscosity was calculated using Poiseuille's equation for Newtonian liquids.

$$\text{Apparent Viscosity} = \eta = \pi R^4 P/8LQ \qquad (1)$$

where:

η = apparent viscosity in lbs.-sec. per sq. in.
π = 3.14
R = radius of orifice bore in inches
P = pressure causing flow in psi
L = length of orifice bore in inches
Q = volume displacement of piston in cubic inches per second

ASTM D1238-57T Extrusion Test—This extrusion plastometer is a gas pressure viscometer with a capillary orifice of specified length and diameter (0.0825" diameter, 0.315" long). The plastic material is forced through the orifice by a steel ball under prescribed conditions of temperature and pressure. The extrudate is collected at 3 or 6 minute intervals and weighed. The flow rate is reported as the rate of extrusion in grams per 10 minutes.

A premolded plug of the thermoplastic was placed in the plastometer and heated to 500°F (260°C). The pressure was applied and the times started. The initial 5-minute extrudate was discarded and subsequent extrudates were collected and weighed.

Three orifices were used in this investigation.

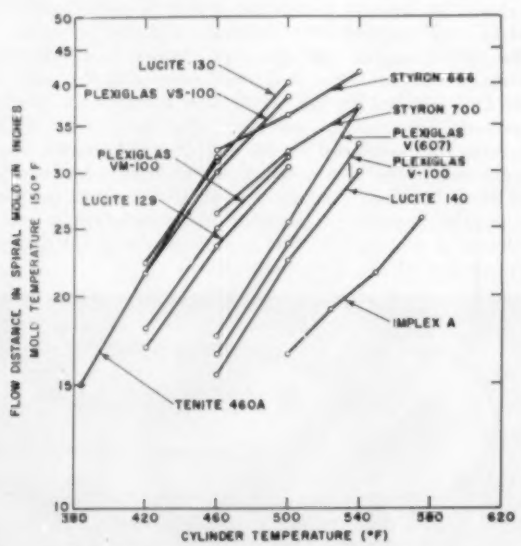

Figure 2. Spiral flow of several thermoplastics

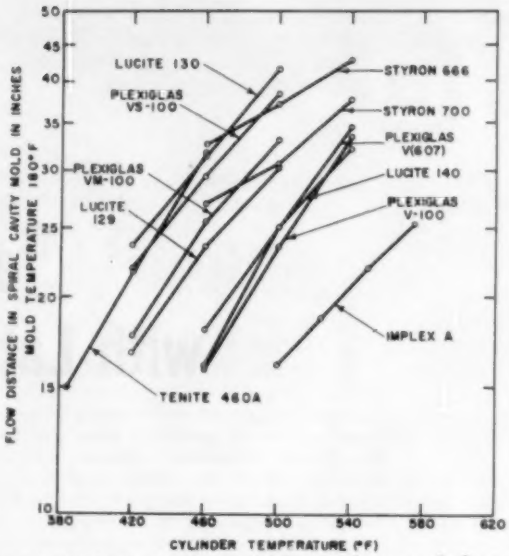

Figure 3. Spiral cavity mold flow of several thermoplastics

Orifice	Diameter	Length	Length/Diameter Ratio
A	0.0407"	0.315"	7.7
B	0.0825"	0.315"	3.8
C	0.0825"	0.156"	1.9

The apparent viscosity, shearing stress, and shearing rate were calculated according to the classical theory for Newtonian liquids using the following formulae:—

$$\text{apparent viscosity} = \eta = \pi R^4 P/8LQ, \text{ lb.-sec. per sq.in.} \qquad (2)$$

$$\text{shearing-stress} = S = RP/2L, \text{ PSI} \qquad (3)$$

$$\text{shearing rate} = \mu = 4Q/\pi R^3, \text{ seconds}^{-1} \qquad (4)$$

where

η = apparent viscosity in lbs. sec. per sq. in.
S = shearing stress in PSI
μ = shearing rate in seconds^{-1}

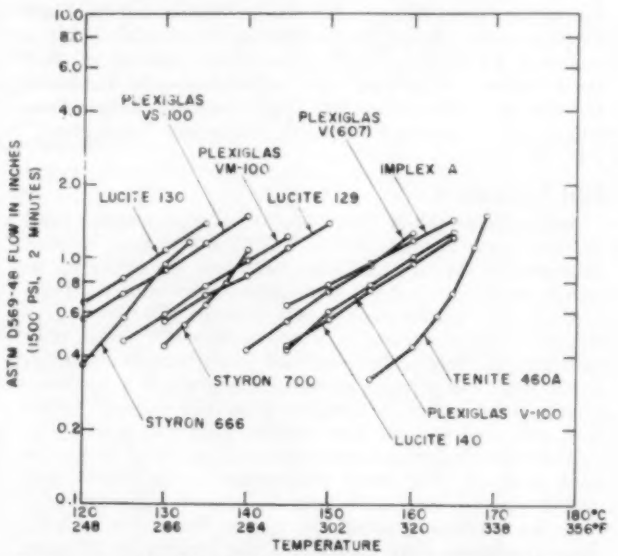

Figure 4. ASTM D569-48 flow of several thermoplastics

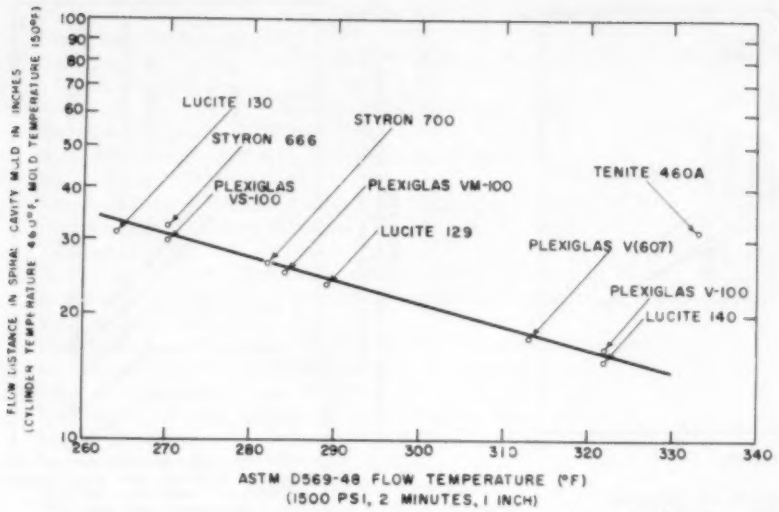

Figure 5. Correlation between flow temperature (ASTM D569-48) and flow distance in a spiral cavity mold of several thermoplastics

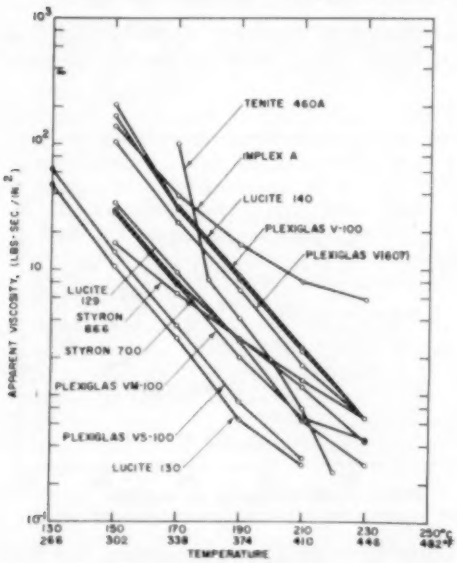

Figure 6. Extrusion of several thermoplastics at an apparent shearing rate of 2.67 seconds^{-1}

$\pi = 3.14$
R = radius of orifice bore in inches
L = length of orifice bore in inches
Q = flow rate, cubic inches per second
P = applied pressure in PSI (gauge)

The volume flow rate was calculated using the following factors for the various chemically similar materials.

	Acrylic	Modified Acrylic	Styrene
specific gravity, 77°F (25°C)	1.18	1.12	1.06
coefficient of cubic thermal expansion, in 10^{-4}/°F units	13.2	14.7	12.0
approximate specific volume at 500°F (260/C), cubic in./pound	24.7	26.2	27.4

These factors are approximate but sufficiently accurate in view of the assumption that the coefficient is constant over the temperature range involved.

Brabender Plastograph Consistency Test—The C. W. Brabender plastograph is a commercially available instrument. The roller blades in the mixing head are driven by a motor which is suspended between floating bearings. The torque produced by the blades as they turn in the material is transmitted through a series of levers to a direct-reading balance which is calibrated in meter-gram units and a strip chart provides a continuous record of the consistency. The mixing head has a working capacity of 50 cc. It is heated at 5° C per minute by circulating hot oil from a temperature bath through a jacket that surrounds the mixing head. The temperature of the material is obtained by means of a thermocouple located in the base of the mixing head.

A comparison of *Figures 2 and 3* shows that a 30°F change in mold temperature has only a minor effect on the spiral-cavity flow distance. The cylinder temperature is a major factor in influencing the flow distance. There is a different response of the three types of plastics to temperature changes. The steep slope of the cellulose acetate-butyrate indicates a sharper change of flow distance with temperature. The flow distance of all the acrylic polymers fall on essentially parallel lines, displaced by but somewhat less influenced by temperature. The curves for the two polystyrenes are essentially parallel and least influenced by injection cylinder temperature.

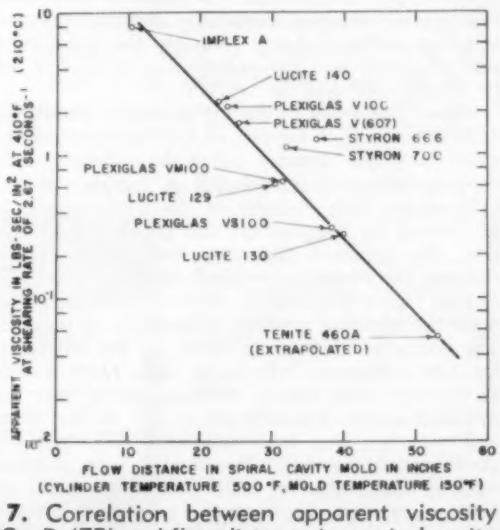

Figure 7. Correlation between apparent viscosity (R & H Co. P-47B) and flow distance in a spiral cavity mold of several thermoplastics

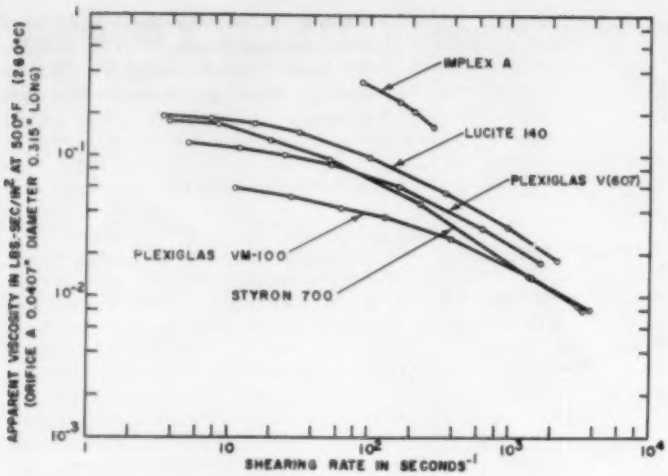

Figure 8. ASTM D 1238-52T extrusion of several thermoplastics

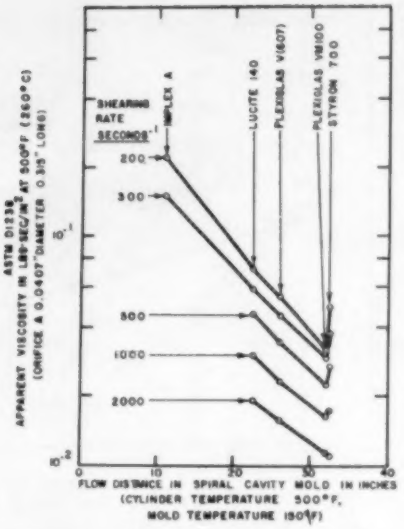

Figure 9. Correlation of apparent viscosity and flow distance in a spiral cavity mold of several thermoplastics

Figure 4 shows standard ASTM D569 flow test data for the same group of plastics. Again it is apparent that the slopes of the flow lines are essentially parallel for a chemical class of material, but different for different classes. Note that these data show the most rapid change of flow with temperature for cellulose acetate-butyrate and polystyrenes and a less steep change for the acrylics. These differences are not consistent with the data obtained with the spiral cavity mold.

Figure 5 is a plot of the log spiral-cavity flow distance under one particular set of conditions against ASTM flow temperature. All the acrylics and the two polystyrene samples fall on a straight line when so plotted, but the one cellulose acetate-butyrate sample clearly does not follow this pattern. Similar plots for other specific molding conditions on the spiral flow mold show the same situation.

Figure 6 shows the apparent viscosity vs temperature for these materials when extruded at a shearing rate of 2.67 seconds^{-1}. This shearing rate is considerably lower than those involved in production molding machines where shearing rates of 10^3 to 10^4 seconds^{-1} are not uncommon. The logarithm of apparent viscosity vs temperature plot as essentially straight lines. The slopes of these curves vary considerably for the chemically different polymers with cellulose acetate-butyrate showing the greatest temperature sensitivity and the polystyrenes to be less influenced by temperature than the acrylics.

Figure 7 is a plot of the log apparent viscosity at 410°F (210°C) at a shearing rate of 2.67 seconds^{-1} vs the spiral-cavity mold flow distance. All of the materials, with the exception of the polystyrenes, fall on a straight line.

Since the melt viscosity of the thermoplastic materials is affected by temperature and possibly by the shearing rate, the apparent viscosities were determined at high shearing rates using a modified ASTM D1238-57T method of test. *Figure 8* shows the effect of shearing rate at 500°F upon the apparent viscosity of five (5) of these materials. The viscosity-shearing rate curves for the acrylics are similar. The polystyrene falls in the same range but decreases in viscosity more rapidly with increasing shear rate. The modified acrylic was difficult to test at this temperature and pressure. Due to instrumental difficulties no results above approximately 3000 seconds^{-1} were obtained. At a cylinder temperature of 500°F, the spiral-cavity mold flow tests relate most closely to the present viscosity observations when the mold temperature is 150°F, as shown on *Figure 9*. Here, the best correlation appears at a shearing rate of about 2000 seconds^{-1}. Note that at low shearing rates the points for polystyrene do not correlate with the other materials. As the shearing rate approaches 2000 seconds^{-1}, however, the correlation becomes quite good.

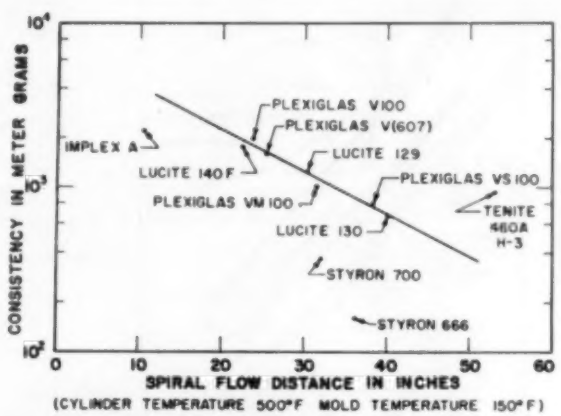

Figure 10. Correlation between consistency and flow distance—Brabender plastograph at 410°F mixed slowly

Figure 10 shows the correlation between consistency and the spiral-cavity mold flow distance. The chemically similar materials fall on a straight line; the others do not.

Thus, if only one chemical class of molding materials is being considered, it is possible to infer the flow data from simple tests with no apparent difficulty. If, however, different types of plastics are compared, these simple tests may not properly predict the behavior in an injection mold. It appears that a test operating at high shearing rates is required to obtain universal correlation. Additional correlations of such tests with spiral-cavity mold flow measurements on other thermoplastics are recommended.

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Acknowledgment

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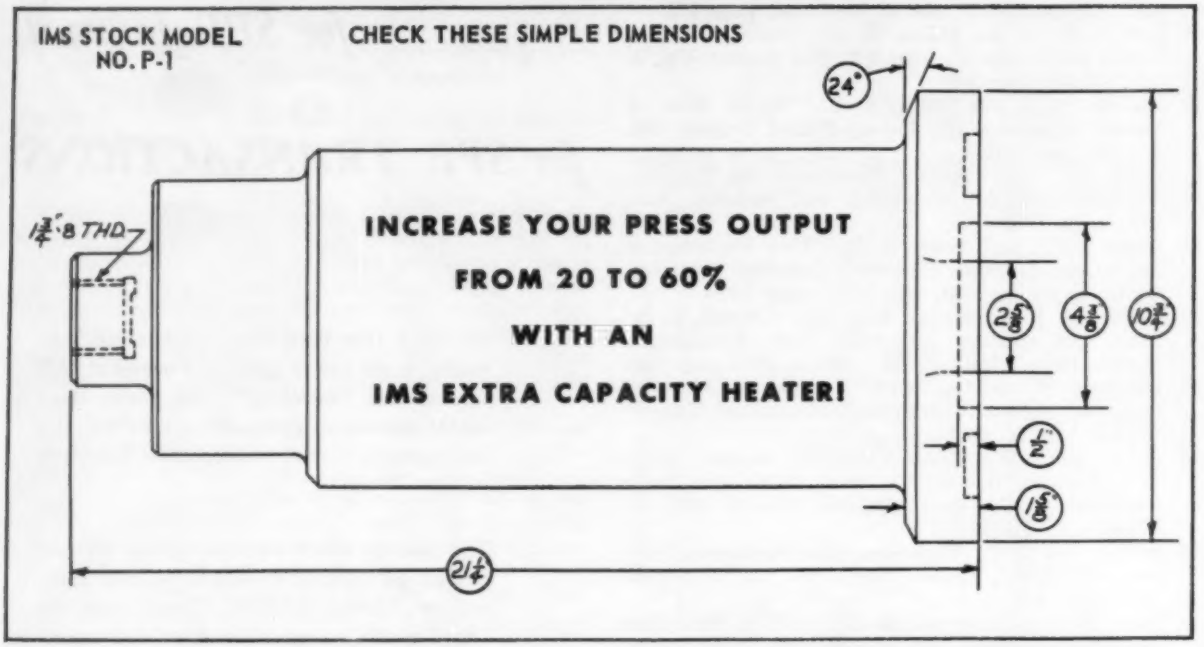

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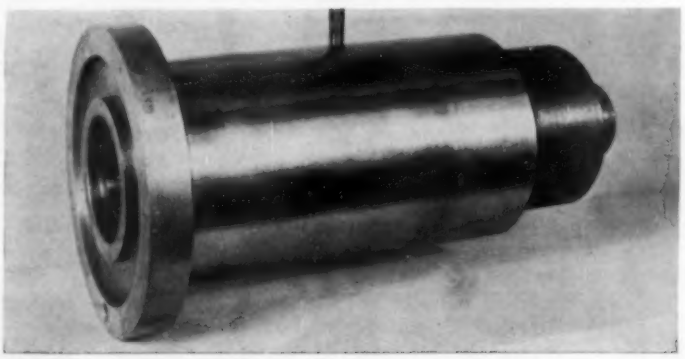

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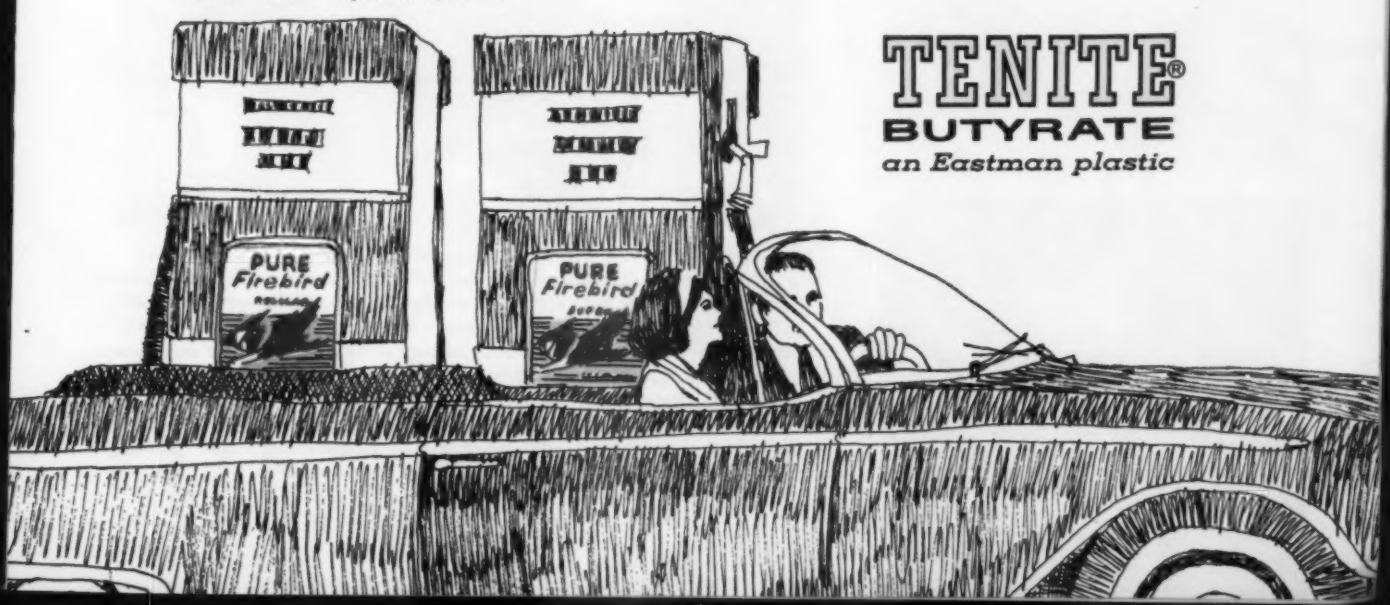

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At its meeting in Detroit on October 9, the SPE Council elected James R. Lampman 1962 President of the Society. Other Officers for the coming year will be John M. Berutich, Vice President Engineering; Richard B. Bishop, Vice President, Administration; George P. Kovach, Secretary; and Samuel H. Greenwood, Treasurer. All will take office at the Annual Business Meeting of the Society on January 31, 1962 in Pittsburgh.

James R. Lampman, President. Manager, Organic Chemical Engineering Materials and Process Laboratory, Electronics Div., General Electric Co., Syracuse, N.Y. Graduate of Michigan State University. Joined GE in 1948 and has worked in plastics industry for last 13 years. SPE member since 1955. Instrumental in organizing and is charter member and first President of Central New York Section. Elected first Councilman from that Section for term starting in January, 1958. Chairman, SPE Membership Committee (1959), SPE Secretary (1960), and Vice President, Engineering, and Chairman of Engineering Board (1961). Resident of North Syracuse, N. Y. Married, two sons.

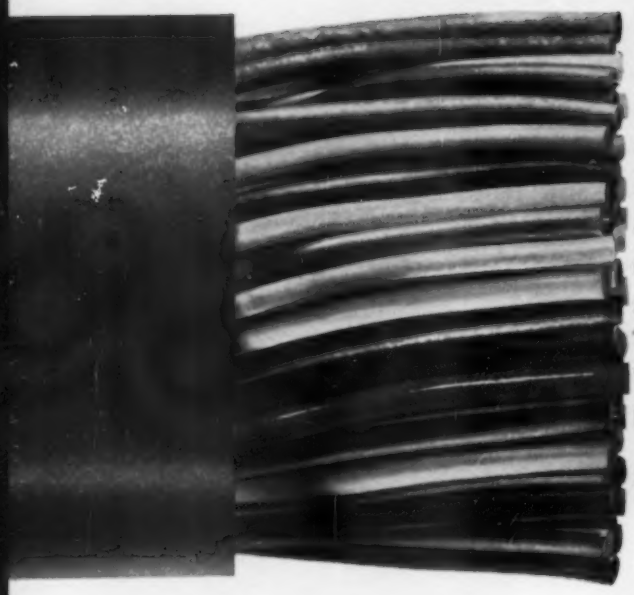
Society Action

John M. Berutich, Vice President, Engineering. Sales Engineer, Haveg Industries, Louisville, Ky. Graduate, Lehigh University. Employed by General Electric, 1937 serving in various engineering, supervisory and sales capacities. 1959 joined Haveg staff when company purchased GE molding operations in Louisville. Veteran of four years in infantry, World War II. Released from active duty as Lt. Col. Past President, Kentuckiana Section and its Councilman for nearly three years. Chairman, Student Membership Subcommittee (1959) and Constitution and By-Laws Committee (1960). SPE Treasurer and member of Finance Committee (1961). Married, four children, resides in Louisville.

Richard B. Bishop, Vice President, Administration. Consultant and Research Associate at Holy Cross College, Worcester, Mass. B.S. and M.S. from Holy Cross. Additional study at Rutgers and Brooklyn Polytechnic Institute. Formerly employed by Socony Mobil Oil and Foster Grant in research and development capacities involving polymers and petrochemicals. Became consultant in 1958 and joined Holy Cross faculty in 1960. Served two terms as Councilman from Philadelphia Section. SPE Treasurer (1948). Elected Pioneer Valley Councilman in April, 1960. Chairman, SPE Inter-Society Relations Committee (1961), member current SPE Education Committee. Married, three girls and one boy. Now lives in North Grafton, Mass.

George P. Kovach, Secretary. Manager, Product Development, Foster Grant Co., Inc., Leominster, Mass. Graduate of Federal Institute of Technology (Vienna, Austria), graduate courses at Massachusetts Institute of Technology and Harvard. Has worked in plastics field since 1940 when first joined Foster Grant. From 1946 to 1953 employed in plastics division of Clopay Corp. and Atlantic Tubing and Rubber Co. and by Nixon Nitration Works. Rejoined Foster Grant in 1953. SPE member since 1950, member of Eastern New England Board since 1955. Former Secretary, Vice President and President (1959) of Section. Term as Councilman began January, 1961. Married, two children. Resident of Lexington, Mass.

Samuel H. Greenwood, Treasurer. District Sales Manager, Press Division, F. J. Stokes Corp., Philadelphia, Penna. Graduate of Case Institute of Technology, 1941. Previously employed by American Meter Co. and Mack Electric before joining Stokes in 1949. Has served in engineering and sales supervisory and managerial posts. SPE member since 1952. A Philadelphia Section Officer prior to being elected Councilman in late 1957 to fill unexpired term. Re-elected for term starting January, 1959. Chairman, RETEC Subcommittee (1960) and Vice Chairman, Engineering Board, and member of SPE Executive Committee (1961). Recently elected Trustee of the Plastics Institute of America. Married, three sons and one daughter. Lives in Abbington, Penna.



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SECTION NEWS

Akron

Lecture Series Begins A series of 11 lectures on Plastics Materials, Their Properties and Applications, began Sept. 26 at Akron University, evening division.

Guest speaker for the opening lecture was Hiram C. McCann, Editor of Modern Plastics Magazine.

The series, which is being presented in conjunction with the Akron Group, Society of Plastics Engineers, Inc., meets on Tuesday evenings from 8:20-10.15 p.m. Registration is limited to 200 according to Evening Division Dean William A. Rogers, and the fee is $18.

The course is an up-to-date study of this rapidly changing field with emphasis on materials, their properties, and engineered applications.

Barbara Moore
Goodyear Tire & Rubber Co.

Central Indiana

RETEC Well Attended The RETEC held on September 12 in Indianapolis, Indiana, was entitled, Plastics for Tooling. Approximately 168 were in attendance. Among those were—Mr. John N. Berutich, National Treasurer, now Vice-President-Engineering elect; Mr. Thomas A. Bissell, Executive Secretary; and Mr. Robert D. Forger, Administrative Assistant.

The committee which was headed by Mr. Eugene C. Quear of Delco Remy Div., of GMC did an outstanding job. The speakers were well chosen for this program and there were numerous, favorable comments regarding the information obtained from this RETEC.

The luncheon speaker, Mr. Roger D. Branigin, a lawyer from Lafayette, Indiana gave us a very humorous, as well as "food for thought" type of talk entitled, Plastic Engineers in Orbit. On the serious side of his speech he emphasized the importance of education in all fields of industry and the furtherance of this education by all members of organizations such as SPE.

M. L. Brummer
Rohm & Haas Co.

Rochester

Pressure Transducers The September dinner meeting was held at Logan's on September 11 with 42 members and guests in attendance.

Our speaker, Mr. Glenn Pettit, of the Barber-Coleman Company, delivered an excellent paper on Pressure Transducers for the Plastic Industry. His presentation, illustrated by slides, showed how variations in weigh feed, temperature and inconsistent machine cycling all contribute to non-uniform molded parts and how this could be corrected by using a pressure transducer mounted in the nozzle of an injection machine. Feedback control from the transducer would adjust for these deviations and insure more uniform molded parts. Mr. Pettit's talk was followed by an interesting question and answer period.

Richard Melville
Taylor Instrument Companies

Pioneer Valley

Research Equipment Donated to Holy Cross Keith W. Lauer (second from right), President of SPE's Pioneer Valley Section, presents a check for $1500 to Rev. Bernard A. Fiekers, S.J. (second from left), Chairman of the Chemistry Department of Holy Cross College, Worcester, Mass. Looking on are Richard B. Bishop (left), Research Associate at Holy Cross and Chairman of the Section's Education Committee, and J. Roger Johnston, Chairman of the Section's recent RETEC from which the funds were derived.

The money will be used to buy equipment for experiments involving polymers and plastics. Funds given to the College were the result of a very successful Injection Molding Workshop drawing a total of 120 participants, sponsored at Holy Cross by the Section on April 4 and 5 of this year. In May of 1962, a similar Workshop, developed in conjunction with the Injection Molding PAG, will be sponsored by the Central Ohio Section at Ohio State University.

Over 100 members turned out for the 1961-62 kick off meeting. Mr. William Morgan of Phillips Chemical Co. gave a very informative talk on the "Technique of Blow Molding". This is the second year Mr. Morgan has spoken to our section and his speech, which was accompanied by slides and films, was very well received.

The following officers for the coming year were introduced:

President, Keith Lauer; Vice President, William Oleson; Secretary, Wilmot Weeks; Treasurer, Joseph Coughlin.

Donald J. Paul
Standard Tool Co.

Chicago

Section Scholarship Awarded The Chicago Section Scholarship was awarded to William Cesarotti, a graduate of Lane Technical High School. An honor student who has followed a curriculum of greatly accelerated classes, he is on the Super-Honor Roll and is active in various other activities at Lane as well. He has been working part time.

Three Summer golf outings were enthusiastically attended by members! In October, the first official meeting took place for the new season. Thermoset Molding was the subject October 9 at the Merchants & Manufacturer's Club at the Merchandise Mart. Mr. Louis Korb and Mr. Jack Clarke of Plastics Engineering Co. were the speakers.

James Steiner
A. Shulman, Inc.

Tri-State

Precision Injection Molding Talk The Fall Season began with a Social

(Continued on page 1223)

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Few tests of abrasive, pounding wear can measure up to the repetitive impact of a pair of spiked-heel shoes with a member of the weaker sex aboard. A 110-pound woman exerts a concentrated force of between 1,500 and 3,500 psi with each step (depending upon who's waiting and how late it is).

As the spikes got longer and sharper, steel, rubber and a variety of plastics were tried in the search for a "lift" that would take the punishment without leaving the scars of fashion in floors and carpeting. Then TEXIN, the new moldable urethane elastomer, was developed by Mobay—and the rest is another success story for the well-heeled shoe industry.

This is just another case where changes in product design proved too much for older materials; where only a completely new material could provide the answer.

If you're redesigning a part now that calls for a heavy-duty elastoplastic—one that wears like steel but works like rubber—and can be injection molded or extruded by fast, low-cost production methods, look at TEXIN before you take another step.

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SECTION NEWS

(Continued from page 1221)

Hour and then dinner. The regular meeting was called to order by our new President, Morgan Jones, of the Red Spot Paint & Varnish Co. He introduced his Co-Officers; Vice-President, Bob Hughs, Spencer Chemical Co.; Treasurer, Fred Newlin, Moll Tool & Die Corp.; Secretary, James Dunn, Spencer Chemical Co.

The highlight of the program was a talk given by Bernard Higginson of Universal Match Co., Marion, Ill., on the topic: "Scientific Repetition in Precision Injection Molding." Following a question and answer session, announcement was made that the October meeting would feature a tour of the General Electric Lexan Plant in Mt. Vernon, Ind.

Carl J. Doughty
Moll Tool & Die Corp.

Milwaukee

Polypropylene Symposium Our 1961 Kick-Off Meeting was a huge success with 75 members and guests present. After a delicious smorgasbord, Jim Hearons, our new president, briefed the group on functions of the national activities during the summer season. He then introduced all of the new Section officers.

The talk for the evening was titled: Symposium on Polypropylene, given by Mr. R. N. Pim, Manager Sales Service, AviSun Corp.; and Mr. J. C. Warren, Manager Sales, AviSun Corp. Slides and samples accompanied their presentation, and many questions were asked by the group before the meeting was closed.

C. H. Strong
Union Carbide Plastics Co.

Kentuckiana

Celcon Mr. A. R. Ross and Mr. "Scotty" Eisele of the Celanese Polymer Company introduced Celcon to the Kentuckiana Chapter at its first meeting of the season. As one of the recent additions to the group of plastic engineering materials, Celcon offers resistance to stress and temperature for a period of time in most environments. An assortment of slides showing comparative test results rounded out a very informative presentation.

Officers for the year were introduced:

R. O. Carhart, General Electric, President; H. G. Cooke, Jones-Dabney, Vice President; W. McWhorter, Jones-Dabney, Secretary; and R. N. Jereau, Tube Turns, Treasurer.

George A. Polk
General Electric Co.

Southern

Molding Machines Reviewed The first meeting was called to order by President Clarence Ballentine at the Architects & Engineers Institute on Monday, September 25th.

Twenty-two Section members and 8 guests heard a comparison of extrusion type and plunger type molding machines by Mr. L. W. Meyer of the Plastics Technical Service section of The Dow Chemical Co. He covered the history, basic types, operations, performance characteristics and future outlooks for this type equipment.

The showing of the Plastics in Buildings traveling exhibit to be sponsored by the Southern Section, will be from November 8th to November 22nd, 1961, at the Architects & Engineers Institute, Inc., 230 Spring St., N.W., Atlanta, Ga.

David P. Holt
The Dow Chemical Co.

Ontario

"Plastics Vs Corrosion" Extra seating had to be provided for the talk by William Henderson, Development Department, Electric Reduction Co. of Canada Ltd., Toronto. It was the first SPE meeting this Fall, and was held with the National Association of Corrosion Engineers. About 130 attended.

Mr. Henderson's subject, "Plastics vs Corrosion" covered the whole spectrum of plastics and high polymer materials available to man in his fight against corrosion. Describing the molecular make-up of most plastics and rubbers, he explained why they have particular properties and how much of a blessing or a liability these properties are.

Arthur Painter
Canadian Plastics

Buffalo

Silicones In Laminating Applications The September meeting was held at the Continental Inn on September 11.

The guest speaker, Dr. John B. Toogood, spoke on the use of silicone materials in various laminating applications. After a brief review of the chemistry of silicone polymers, the end products in which the silicones are used were discussed.

Dr. Toogood, a native of Wales, is well qualified in his subject. He is head of the technical service group of the Silicones Division, Union Carbide Corporation.

Andrew J. Hammerl
Durez Plastics Division,
Hooker Chemical Corp.

St. Louis

Celcon Discussed The September meeting at Holiday Inn South on September 18, attracted 39 members and guests.

Mr. A. Richard Ross, Product Development Engineer for Celanese Polymer Co. spoke on "Celcon", a new engineering plastic. The properties, molding characteristics, and applications of this new thermoplastic resin were discussed and compared with existing polymers.

Peter W. Spink
Monsanto Chemical Co.

Philadelphia

"Joining of Plastics" The '61-'62 season of the Philadelphia season got off to an excellent start with a program on the "Joining of Plastics". Meeting Chairman Frank Connell had two speakers, Richard Geuder of Du Pont who spoke on mechanical methods of joining plastics and Thomas Scarpa of International Ultrasonics Company who reviewed the status of ultrasonics for welding plastics.

Mr. Geuder started his talk with a movie showing the various methods—spin welding, heat fusion, cold heading, riveting, etc.—of joining similar or dissimilar plastic parts. He then discussed the advantages and limitations of the various methods.

Mr. Scarpa described how ultrasonics are being used to weld thin sheets of plastics together. Particularly successful has been the forming of endless belts from polyester film. Ultrasonics have proven very useful in areas where heat sealing is not satisfactory.

George R. DeHoff
E. I. du Pont de Nemours & Co., Inc.

Connecticut

Screw Plasticizing vs. Ram-Torpedo Plasticizing Injection Molding Machines The guest speaker at the September meeting was Mr. J. G. Fuller, Sales Manager of Ankerwerk International, Santa Ana, California.

Six advantages which screw plasticizing molding machines offer over conventional ram-torpedo type machines were discussed as follows:

Much greater mixing of the melt; High speed injection of the melt and more uniform speed of injection; The utilization of lower injection pressures; A reduction of strains in molded pieces; With crystalline materials a more uniform crystalline structure in the molded part; and greater ease of coloring and changing materials.

Mr. Fuller also went over several case histories showing samples to il-

(Continued on page 1227)

TECHNICAL MEETINGS CALENDAR

1961 REGIONAL TECHNICAL CONFERENCES (RETEC)

November 15—Vinyl Plastics in the Household sponsored by New York Section with cooperation of Vinyl Plastics PAG, Statler Hilton Hotel, New York, N.Y. Chairman: Saul Gobstein, c/o Ferro Chemical Co., Box 607, Emerson, N. J.

December 1—Plastics Screw Injection Molding sponsored by Cleveland Section, Cleveland Engineering Society Building, Cleveland, Ohio. Chairman: Edward J. Haskins, c/o Injection Molders Supply Co., 17601 South Miles Road, Cleveland 28, Ohio.

ANNUAL TECHNICAL CONFERENCES (ANTEC)

January 30-February 2, 1962—18th ANTEC, Penn-Sheraton Hotel, Pittsburgh, Pa. Sponsored by Pittsburgh Section. General Chairman: John E. Parks, H.P.M. Division, Koehring Co., 512 Empire Building, Pittsburgh 22, Pa.

February 24-March 1, 1963—19th ANTEC, Statler Hilton and Biltmore Hotels, Los Angeles, Calif.

BRI CONFERENCE

November 28-30—1961 Fall Conference of the Building Research Institute. Mayflower Hotel, Washington, D. C. Chairmen: Prefinishing, W. E. Kemp, Koppers Co. Performance of Plastics in Building, D. R. Grey, Dow Chemical Co. Mechanical Fasteners for Wood, J. Godley, Gregory Industries. Design for Nuclear Age, G. H. Albright, Pennsylvania State University. Identification of Colors of Buildings, M. D. Folley, Sargent-Webster-Crenshaw & Folley. Methods of Building Cost Analysis, C. Bogart, A. T. & T.

REINFORCED PLASTICS

February 6-8—SPI Reinforced Plastics Division, Technical Conference, Edgewater Beach Hotel, Chicago.

CORROSION CONFERENCE

October 30-November 2—Houston; November 27-December 1—Miami; Plastics to Combat Corrosion will be covered at these regional conferences of the National Association of Corrosion Engineers.

ASME CONFERENCE

November 26-December 1, American Society of Mechanical Engineers Annual Winter Meeting, Statler Hilton Hotel, New York, N. Y.

PLANT ENGINEERING

January 22-25, 1962—National Plant Engineering and Maintenance Show, produced by Clapp and Poliak Inc., Convention Hall, Philadelphia, Pa.

WESTERN SPI CONFERENCE

April 4-6—Nineteenth Western Section Conference of the Society of the Plastics Industry, Hotel Del Coronado, Coronado, California. General Chairman: F. Rea, Western Plastics Magazine, San Francisco, Calif.

SPACE AGE EXPOSITION

April 25-29—Western Space Age Industries and Engineering Exposition Conferences, sponsored by local governments and private industry in cooperation with U.S. Government Agencies, Cow Palace, San Francisco. Exposition Manager: W. J. Wilkin, Lykke-Wilkin Associates.

EUROPEAN PLASTICS AND RUBBER

May 18-29—European Plastics and Rubber Conference, sponsored by the International Union of Pure and Applied Chemistry, Terrace "R", Parc des Expositions, Paris, France. General Agents: Europlastique, Palais des Florailes, Parc-Ghent/Belgium.

WESTERN PACKAGING

July 17-19—Tenth Annual Western Packaging Exposition, produced by Clapp and Poliak, Brook's Hall, San Francisco, Calif. Co-chairmen: W. H. Jaenicke, consultant and K. O. Dean, Good Packaging.

INTERNATIONAL CONGRESS

October 18-25—Third International Plastics Exposition "Microplast", Utrecht, Holland, proceeded by the Plastics and Problems of Choice Congress, October 15-17, in Amsterdam.

SECTION NEWS

Binghamton

The first meeting since the regular season closed last May was on September 28, with approximately 60 members and guests present at the Vestal Steak House to hear a dual topic program about two new materials.

Mr. W. E. Coleman of the J. G. Baker Chemical Company presented an "Introduction to Bavic II". This is a new water white acrylic type polymer very similar to polymethyl methacrylate, but with more heat resistance.

Mr. Richard C. Burck of the Mobay Chemical Company talked about "Texan Moldable Urethane". This material was developed to give molders and extruders the immediate market advantage of cast urethanes. It was stated that the same abrasion resistance and strength of cast urethanes are available with the added advantage that, without post-curing, scrap and sprues can be recycled.

The talks were well illustrated with slides, films, and molded articles of the new materials.

T. E. Battaglini
IBM Corporation Plastics Laboratory

Southern California

"Celcon" Talk Ninety-eight members and guests of SPE opened the new season at Rodger Young Auditorium in Los Angeles. After dinner the incoming officers of the 1961-62 year were introduced, and announcements of future Society activities were kept brief. Reports of job openings, and available personnel, in the Industry attracted more than usual attention.

Subject for the evening was "CELCON—A new Engineering Plastic". Speaker was C. B. Littlefield of Celanese Polymer Co., Technical Sales Group. Mr. Littlefield brought a condensed story of the new Acetal Copolymer, and illustrated its possibilities with slide charts, pictures, molded and blown molded samples.

Charles C. Zimmerman
West Coast Plastics Distributors, Inc.

Eastern New England

Dr. R. Ehlers who was recently elected E.N.E. Section President

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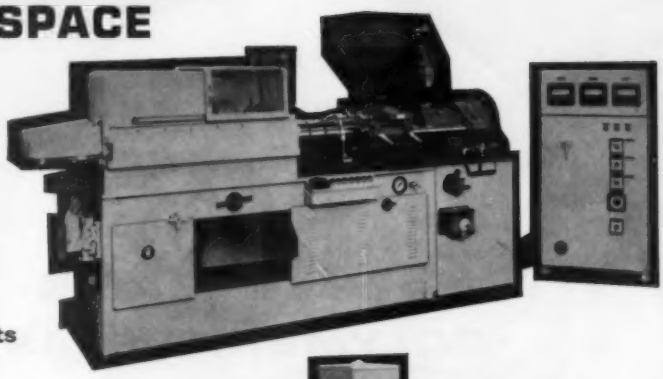

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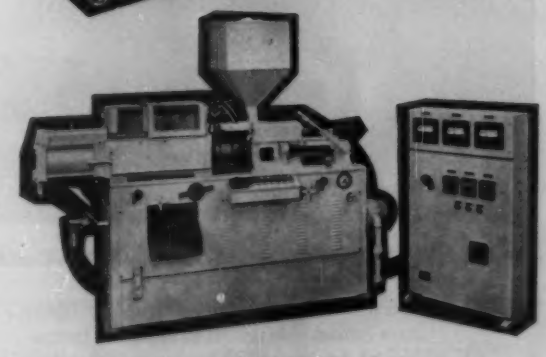
MODEL KS6-100-50

The KS6-100-50 is a highly efficient screw plasticizing injection unit designed to handle critical materials and the newly developed thermo-plastics. A reciprocating screw acts as the injection ram and melt homogenizer producing better parts consistently. Moderately priced, this machine satisfies the needs of the progressive molder.

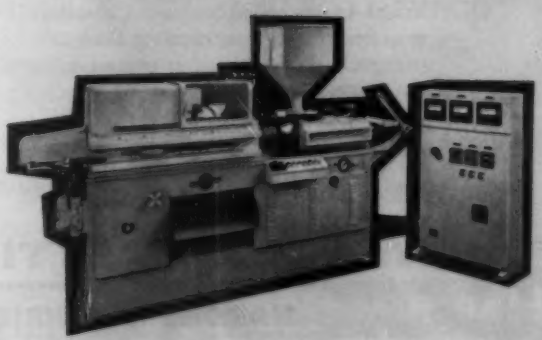
AUTOMOLDER*
MODEL K3-100-50

In this simply-designed, fully hydraulic machine there are features not found in other small molding machines. The K3-100-50 produces 1500 automatic cycles per hour with a clamping unit closing force of 100 tons. Being self-contained the K3-100-50 uses only 10' x 3' x 6' of floor space.



AUTOMOLDER*
MODEL K2-50-50

This is a smaller two ounce machine which may be electrically or cam operated. A unique sub-plate mounted valve system eliminates costly maintenance and offers easy access. The K2-50-50 offers production capacities for a minimum initial investment.



AUTOMOLDER*
MODEL K2-100-50

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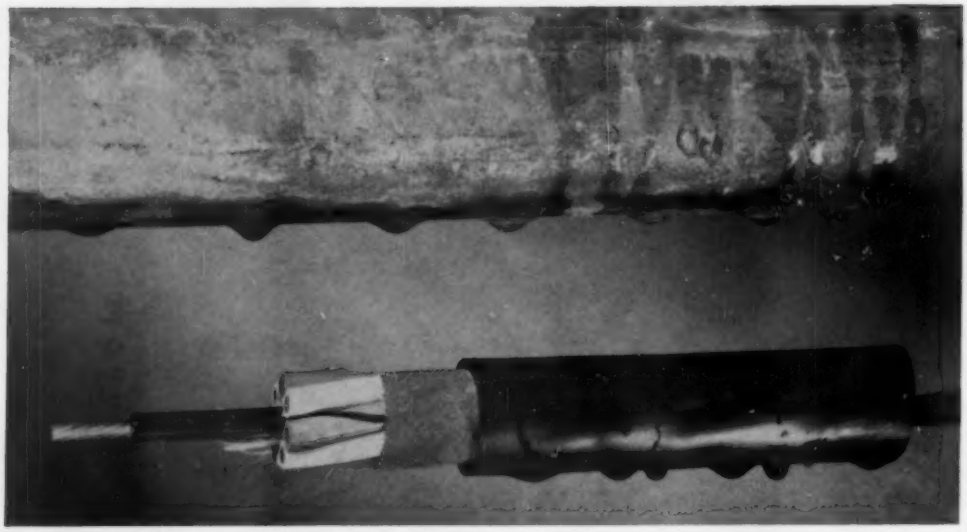

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Latest developments in Harflex 330 produce remarkable results in electrical formulations. In an unfilled compound, electrical measurements were outstanding. Dielectric strength, both dry and after immersion in water, was very high.

Formulators also find Harflex 330 a non-migratory plasticizer with good color, excellent resistance to transfer of odor and taste and good resistance to extraction by water, soapy water, oil and gasoline.

Featuring unheard of uniformity and excellent compatibility with most other plasticizers, including epoxy types, you'll find Harflex 330 incorporates a host of qualities found only in far more expensive plasticizers.

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SECTION NEWS

(Continued from page 1223)

lustrate the advantages of screw plasticizing injection molding machines.

Robert F. Flaherty
Spencer Chemical Company

Miami Valley

International Flavor at Miami Valley Fifty members listened to an interesting and timely presentation of the advantages and limitations of the most recent developments in "Screw Injection Molding Equipment", by Mr. W. Ben Evans of National Automatic Tool Company of Richmond, Indiana, on September 7th at the Golden Lamb Hotel, Lebanon, Ohio.

An international atmosphere was injected by the presence of Y. Shizuki and S. Nakagawa, representing the Mitsubishi interests of Japan, and Malvern Jury and Karl Gilbert of Reifenhauser, K. G., Germany, co-developers of the systems.

The recent controversy in current publications over the advantages and future of this latest mechanical approach to molding made this a most instructive and informative meeting.

Roger A. Houston
Recto Molded Products, Inc.

Newark

Double Session: Plastics Design and Prototype Techniques Program Chairman Bob Gilden announced plans to have double sessions for the technical programs throughout the coming year in order to better satisfy the interests of more of the nine hundred Newark Section members. A plant visit to the Celanese Corp. was announced for the November meeting. The two concurrent sessions held at the Military Park Hotel in Newark on September 13 were concerned with "Plastics in Design" and "Techniques for Prototype and Short Run Production."

The first of three speakers in the design session was Paul Limbach of Union Carbide Plastics Co.: "Mechanical Design of Plastics."

Dr. Charles Williamson of Enjay Laboratories discussed the "Use of Plastics Design Data in Injection Molding Applications," and Leo Gans of Anchor Plastics, spoke on "Design of Extruded Plastics."

In the session on prototype techniques, Mr. Ed Power of Bell Laboratories was the moderator. Mr. Ed Ferrari of General Electric Co. spoke on "Prototype Techniques," and Mr. O. J. Seeds of Cerro Corp. discussed "Low Melting Metals for Mold Making."

R. E. Christensen
Union Carbide Plastics Co.

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NEW BOOKS

PHYSICAL CHEMISTRY OF MACROMOLECULES

by Charles Tanford (John Wiley & Sons, Inc., $18.00)

This book covers the major areas of the physical chemistry of polymers. All classes of polymers are dealt with from a uniform point of view.

It is not an elementary textbook nor is it written primarily for the expert. Each topic begins with a step-by-step discussion of the underlying theory and then the predictions of the theory are compared to experimental data. Lastly, the concepts of molecular behavior are discussed and areas needing greater understanding are delineated.

The emphasis on polymers of biological interest is, of course, consistent with the author's field of research. This adds to the usefulness of the book to those who wish to know more about one of the most exciting areas of polymer research.

It is recommended reading for physical chemists having interests in the field of polymers.

Dr. E. H. Merz
Director of Research
Materials Formulation & Evaluation Dept.
Continental Can Co., Inc.

POLYMERIC MATERIALS

by Charles C. Winding and Gordon D. Hiatt (Mc Graw Hill Book Company, Inc., New York 1961, 406 pp., $12.00)

This book begins as an introduction to the chemistry and various properties of polymeric materials: polymeric structure, polymerization reactions, solubility, viscosity, molecular size, osmotic pressure, hardness, density, electrical and thermal properties and many others. The following chapters deal with the applications of polymeric materials in coatings, paints, lacquers and varnishes, in molding, casting, extrusion lamination and foams.

The authors describe the natural products and their derivatives: resins (fossil and live), lignin, cellulose and its derivatives and proteins. The last chapters are devoted to condensation polymers (phenolics, amino resins, polyesters, polyurethanes, etc.) the ethenic polymers (polyvinyls, vinyls and acrylics) silicones and rubbers.

This book is well written; the authors have covered their subject comprehensively and made it pleasant to read and easy to consult. There are many figures and photographs.

Dr. Louis C. Barail,
Barail Associates

REINFORCED PLASTICS FOR ROCKETS AND AIRCRAFT (A SYMPOSIUM)

A.S.T.M. Symposium Papers (Amer. Soc. for Testing Matls. 132 pp., $5.50)

Here is a relatively small volume, presenting in full the nine papers presented in San Francisco October 14-15, 1959, at the Third Pacific Area National Meeting of A.S.T.M. It has been given the ASTM Special Technical Publication Number 279.

All of the material contained in this publication is useful, basic, and comprehensive. All of the data are of great interest to those involved in missile and space research. If any criticism is to be given, it can only be on two academic points, namely, that the data and information are well over two years old—and in this business, that's almost prehistoric —and that the price of the volume, while possibly not exorbitant for an industrial library, is certainly beyond the normal reach of the working engineer, for what is, after all, a summary of presented papers, with a limited market.

In favor of the volume—and much should be submitted in its favor—it must be said that the papers were written and presented by men who are accepted authorities in their particular fields. Many photographs, curves, and tables are included with each paper, and the dated nature of the material does not detract from the fact that all of it is useful information, as far as it goes. For the newcomer in the field, the book will be of value as a reference source, and for the active worker it may serve as a refresher course.

Samuel Oleesky
Plastics Consultant

PLASTICS IN NUCLEAR ENGINEERING

by James O. Turner (Reinhold Publishing Corp., pp. 140, $5.50)

The author, James Turner, has for several years been working with the Radiation Laboratories at the University of California (Berkeley), in the design and development of radiation generators and detectors. Thus he has been in the forefront of such work, to which he has made many and notable contributions.

The book deals with the applications of plastics in nuclear science and technology. The great number of uses, the variety of plastics involved, and the usually severe conditions of use, all form a story of tremendous interest to all plastics engineers, whether associated with nuclear work or not. The book, incidentally, provides a sort of introduction to nuclear "machinery" that is important and fascinating in itself. It is quite authoritative, makes absorbing reading, and is one of the growing list of Reinhold Plastics Applications Series.

Dr. Jesse H. Day
Professor, Chairman, Chemistry Dept. Ohio University;
Editor Emeritus, SPE Journal

ELECTRONIC PACKAGING WITH RESINS

by Charles Harper (Mc Graw Hill Book Co., New York 1961, 339 pp., $11.00)

This reference book describes the various methods and materials used for the packaging of electrical systems and parts. The materials include polyesters and derivatives, epoxy resins, silicones, methanes, polysulfides, foams and other embedding materials. Modifiers include fillers and colorants. The following chapters deal with thermally and electrically conductive compounds, embedded packaging, tools, process equipment and manufacturing controls of all kinds.

As can be gathered from the above, this is a highly specialized treatise. As such it may have a relatively limited audience now, but the development of the electronic and plastic industries is so rapid that it wil be indispensible very soon to engineers in both fields.

Dr. Louis C. Barail,
Barail Associates

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PLASTICS AROUND THE WORLD

This month's column has been made possible through the contributions of these abstracters:
Hans Mayer (Industries des Plastiques Modernes)
H. O. Pierson (L'Officiel des Matieres Plastiques and Pensez Plastiques)
Leonard Buchoff (Materials in Design Engineering)
Alfred Alk (Materie Plastiche and Poliplasti)
Walter A. Gammel, Sr. (Rubber and Plastics Age)
G. Gruenwald (Kunststoff-Rundschau)
G. Kracht (Kunststoffe and Plaste und Kautschuk)

France

INDUSTRIE DES PLASTIQUES MODERNES

JULY 1961

The Extent Of Shrinkage In The Injection Molding of Low Pressure Polyethylene—Authors: Dr. Beuschel and Dr. Peters.

The shrinkage of low pressure injection molded articles during the cooling cycle is considerable due to the crystalline nature of the material. It is bound to be larger in the direction of the flow of the material than in the perpendicular. This phenomenon can result in internal tensions in the molded specimen and may lead to cracking.

The authors examine the causes of this behavior pattern, describe suitable methods of establishing correct measurements of the internal tensions in the molded product and suggest possible steps in the production process towards minimizing this occurrence.

PENSEZ PLASTIQUES

JULY, AUGUST 1961

Polypropylene—pp. 5-13. Author: M. G. Duglas

This is the third and last part of this study (see May and June issues). The technique of biaxial stretching of polypropylene notably improves its physical properties providing that temperature is properly controlled; welding becomes a problem since the molecules must not be reoriented during the process. The development of polypropylene production throughout the world is outlined, including a description of the Humble Oil process.

Molding and Coating Processes by Simultaneous Projection of Fibers and Resins—667-669

This new process is particularly designed for reinforced plastic moldings and coatings. It permits the simultaneous application of glass fibers and polyester resins with only one spray gun. Fibers are fed into the gun by means of air pressure. The resin is divided into two equal parts, one of which is catalyzed and the other accelerated. Mixture is obtained at the nozzle. Advantages are: complete impregnation of the fibers, good homogeneity, low cost.

England

RUBBER AND PLASTICS AGE

MARCH 1961

Britain and the Russian Seven Year Plan—pp. 15-18

Between now and 1965 Russia plans to expand her plastics production to 90% of the U.S.A.'s This will require much equipment for which England feels she is a natural supplier. England would also furnish know-how, intermediate products, printed circuit laminate blanks and finished goods.

Forty-six companies selling equipment and raw materials exhibited at the Rubber and Plastics Goods Exhibit and Equipment in Moscow during the Trade Fair May 19-June 4, 1961.

Mechanisms of Stereospecific Polymerization of Dienes.—pp. 267-273. Author: Prof. C. E. H. Bawn

The author discusses the catalysts used in polymerization of dienes, especially butadiene and isoprene.

The ratio of the placements, isotactic or sydiotactic is temperature dependent. Greater chain regularity will be expected at the lower temperatures polymerization in these free radical initiation polymerizations. Alkali metals and their alkyl polymerize dienes also. Perhaps most important recent observation is that the polymerization of isoprene in hydrocarbon media catalyzed by lithum alkyls gives a cis 1:4 polyiosprene comparable with natural rubber. Six figures, three tables and a well selected bibliography are included in the article.

Italy

POLIPLASTI

MAY-JUNE 1961

The Plastics Materials Industries in Italy in 1960—pp. 9-13

Productive overcapacity is expected to force severe competition in domestic markets and to be challenged by other countries in the export market.

A Meeting With Glass Fibre Reinforced Plastics At the 39th Trade Fair in Milan—pp. 41-51

In 1960 Italy produced nearly 7500 tons of glass reinforced plastics products of which 60% was corrugated or flat sheets, 30%, boats and 10% other applications. A very wide range of products is included in the 10%. The article includes many photographs of products exhibited at the Fair and descriptions of some novel applications.

Recent Applications of Reinforced Plastics in the Building Field—pp. 52-57

Italy's building industry has markedly increased its use of reinforced plastics because of their good mechanical resistance, stability to atmospheric agents and ease of fabrication. It is believed the time has come for studies to provide the engineer with equations and tables similar to those available for steel, wood and reinforced concrete so that greater structural use may be made of reinforced plastics as original materials. A recent application is the roof for a subway station in Milan fabricated from 24 geometrical translucent panels. A Treviso firm has produced a prefabricated house of conventional design using foam filled glass reinforced polyester walls with metallic supports on a concrete foundation. A Milanese firm has a prefabricated one family house whose novel structural design conforms to the capabilities of its raw materials. It is formed of three basic panels a) roof or base b) lateral closure c) side closures either solid or with window or door openings. The structure is self-supporting and strength comes from the beam designs of the panel edges. In plumbing, a novel structure incorporates all the sanitary traps for a bathroom in one unit which is installed below the toilet

bowl. There is said to be a minimum holdup of solid material and easy assembly with either conventional or plastic plumbing fixtures and piping.

JULY 1961

The Plastics Market in 1960—pp. 635-652

The production of plastics in Italy increased 39% over 1959 (220,000 to 296,700 tons) compared to the reported U.S. increase of 28%. The author discusses each basic plastic separately, touching briefly on the major product applications for each and suggests future trends.

Polyester Resin Greenhouses and Covers for Plant Culture-Part I—pp. 693-703

Polyester resins in the form of plane and corrugated sheets have assumed a continually increasing importance in Italian agriculture. They are capable of being adapted to light, portable, strong, resistant structures which compare favorably in cost and maintenance with conventional glass and new polyethylene covered structures. Furthermore their chemical and physical properties show advantages in agricultural production. Various construction methods are described. Illustrations of existing greenhouses, cold frames and other agricultural structures amplify the text.

Germany

PLASTE UND KAUTSCHUK

MAY 1961

Modification of Mechanical Properties of Methacrylate Plastics and Lacquers—pp. 282-287

A methacrylate was used to carry out several polymerization tests. Different catalysts and accelerators were employed. The following properties were determined: abrasion, hardness, erichsen depth, pot life and drying time. The results are summarized.

KUNSTSTOFFE

MAY 1961

Technological Considerations in Processing Polypropylene—pp. 269-276

The molding of thermoplastic materials is generally determined by an interchange between different raw material properties and various molding processes. Taking this into consideration, the author discusses several technological points applying to polypropylene, with special reference to the extrusion of film and pipe, vacuum forming and injection molding. There are fourteen figures and four tables.

Rigid Moltopren, A Polyurethane for Thermal Insulation—pp. 246-251

The present status with regard to the production of moltopren foam is discussed, followed by details concerning the development of raw materials. Most important in this field is the use of new blowing agents and a new type of polyisocyanate. Specific examples are given with particular reference to the insulation of refrigerators and similar items. The article includes ten figures and three tables.

JUNE 1961

Relaxation of Thermal Stresses In Ziegler Polyethylene—pp. 310-312

The article explains the processes involved in the formation of thermal stresses in viscoelastic materials. The influence of time and temperature on the elastic modulus (relaxation modulus) is taken into consideration. Measurements using Ziegler polyethylene designed for pipes are described. Two figures and one table illustrate the article.

H.F. Pre-Heating of Molding Compounds—pp. 332-334

The effect of different types of pretreatment on the dielectric properties of molding compounds is discussed. In addition, the authors describe the effect of moisture and bulk density on the pre-heating temperature reached in the H.F. field. There are four figures and one table.

U.S.A.

MATERIALS IN DESIGN ENGINEERING

JUNE 1961

New Directions in Materials Testing—pp. 117-148

Several authors present a group of excellent critiques of present testing methods and future trends. These are not specifically for plastics, but many of the tests cited are applicable.

Acetal Moldings vs Zinc Die Castings—pp. 105-112

Both materials can be produced by high speed production processes and they are comparable in cost. Zinc is stronger, has higher resistance to impact loads, can withstand higher temperatures, and is a better thermal conductor than acetal. Acetal will not permanently deform as readily, can be used with snap fits and is lighter. Deflashing zinc parts add considerably to cost of some parts. Zinc can be bright plated for good appearance, but metallizing on acetal wears off. Tighter dimensional tolerance can be maintained on zinc parts but acetal's "give" makes this less important.

JULY 1961

Bonded Fibrous Sheets—pp. 97-99

Saturated cellulosics are formed from alpha cellulose-binder combinations. Binders can be vinyl, latex, phenolic or others. Simulated leather goods, gaskets and footwear are made by this process. Advantages are low cost and variety of fabricating techniques and properties available.

Problems In Cryogenic Evaluating & Testing Plastics—pp. 115-118

Tensile and flexural microspecimens are used to reduce the chamber size and time to cool specimen. Fluorocarbons retain some ductility at ultra low temperatures and their strength increases with decrease in crystallinity. A hardness test for crystallinity was developed that eliminates the cost and inconvenience of X-ray diffraction and infra-red absorption techniques.

Polyvinyl Chloride in Potable Water Piping—pp. 653-655

Potable water distribution in PVC or polyethylene piping is well established as safe and economical. The choice of resin is dictated mostly by economic factors in each country. In Italy the advantage lies with PVC which holds about 40% of the production volume. Suspension polymer is preferred because of its greater purity. Incorporating synthetic rubber to increase resiliency without decreasing other qualities is a recent development. The State Sanitary Authority has promulgated a series of standards, summarized here, which limit quantities and composition of stabilizers, lubricants, fillers and other processing aids. The author suggests that conforming pipe be marked with an insignia approved by the Plastics Society.

ABOUT MEMBERS

Wayne W. Bidstrup, development engineer in the Research Department, The Kordite Co., has been named plant technical superintendent. A graduate of Michigan College of Mining and Technology and M.I.T., Mr. Bidstrup was associated with Standard Oil of California and Proctor and Gamble before joining Kordite 4½ years ago.

Edison Technical Services, a plastics consulting and liaison firm, has been formed by **Allan L. Griff.** It will specialize in discovering, reporting and analyzing plastics technology, particularly in extrusion.

Daniel W. Klohs moves up at Nuodex Products Division, Heyden Newport Chemical Corp. as manager of vinyl additives. He will administer sales and technical service under an accelerated program. Mr. Klohs holds a BA degree from Drew University and completed graduate work in organic chemistry at Columbia University. He joined the company in 1958.

Diamond Alkali Co. has announced the promotion of **J. P. Okie** to director of planning, and **Roger G. Richards** as general manager of the plastics division, succeeding Mr. Okie. Mr. Richards was the director of development, before his promotion.

Gerald A. Lessells has been transferred from the Research division to the Polymer Service Laboratory, U.S. Industrial Chemical Co., Division of National Distillers & Chemical Corp. He will serve as group leader, plant assistance.

Dr. Edward T. Kubu has been appointed assistant director of laboratory research at the Central Research Laboratory, Allied Chemical Corp. Dr. Kubu, a graduate of N.Y.U., holds MA and Ph.D. degrees from Princeton and has been with the firm since 1959.

Werner A. H. Eckhardt has been named managing director of the Deutsche Oerlikon-Plastic GMBH, Munich, Germany. He has been sales manager of Perfolan Holding Trust, Liechtenstein and, business manager, Oerlikon-Plastics Ltd., Switzerland.

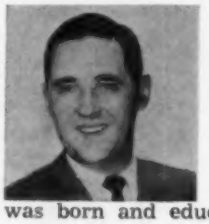
Charles F. Blaich, Jr., was recently appointed supervisor of the Urethane Technical Service laboratory, Rubber Chemicals Dept., American Cyanamid Co. Mr. Blaich, who holds a BS degree in chemistry from Lebanon Valley, has been associated with Carwin Chemical Co. and is the author of several papers on elastomers and finishes.

Franklin E. Eck, formerly marketing manager of chemicals and plastics for Cosden Petroleum Corp., is now the president of a new firm, Cosden Petrochemical Corp., New York, a subsidiary of Cosden Petroleum. Mr. Eck, who has also been associated with Spencer Chemical Co. and American Cyanamid, holds a BS degree in chemical engineering from the University of Notre Dame and a master's in business administration from Harvard.

The Annual Charles Goodyear medal, the rubber industry's highest honor will be awarded to **Dr. Melvin Mooney,** retired United States Rubber Co. scientist whose studies established a sound scientific basis for an understanding of why rubber stretches and "flows", leading to many of today's improvements in rubber processing. The medal will be presented at the American Chemical Society's Division of Rubber Chemistry's Spring meeting next April.

Dr. T. Robert Santelli has been named director of organic research, in a reorganization of the corporate research and development activities of Owens-Illinois Glass Co. He has served as assistant director of research for organic materials and processes since 1959 and has been with the plastics research program since 1956. His new position places upon him the full responsibility for all applied research on sources, properties and processing of organic materials such as plastics and paper.

Val O. Reising has been appointed sales manager of the R-V Foam Division, Arvey Corp., Mr. Reising was with Koppers Co.



F. J. Stokes Corp. has named **F. Theodore Hahn** district manager in charge of their new West Coast facility at Pasadena California. Mr. Hahn has been a field sales engineer for the company in upstate New York since 1957. He was born and educated in Germany, where he was associated with V.D.M. in Frankfurt.

Wallace H. O'Dowd and **John B. Rutherford** have been named sales representatives in the Midwest Region for Rexall Chemical Co., a division of Rexall Drug and Chemical Co. Mr. O'Dowd, responsible for the sale of the line of plastic resins in the St. Louis area, received his BS in industrial management from Kansas University in 1952. Mr. Rutherford, who will sell the same line in the Columbus region. He holds a BA from Harvard College, 1951.

U.S. Industrials Chemicals Co., Division of National Distillers and Chemical Corp. has made known the appointment of **John N. Murray** as Minneapolis District sales manager. He has been with USI since 1955 following his graduation from the University of Illinois with a BS degree in chemical engineering.

DEATHS

William J. Miskella, a member of the Cleveland Section, died July 19. He was the inventor and manufacturer of Vibra-Veyor, and his company, The Miskella Infra-Red Co., Cleveland, manufactured the infra-red heating units used in that machine. He held degrees from the University of North Dakota and Cornell.

Andrew J. Wargo, general foreman of the Mold Die Department, Bryant Electric Co., Bridgeport, Conn., died July 23. A semi-pro football player, he served in the Navy following World War I, and had been in the mold die business for over 30 years. He was a member of the Connecticut Section.

Hamilton Varie, a member of the Philadelphia Section, died recently. He was a mold designer with Stokes Trenton, Inc.

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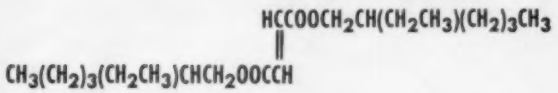

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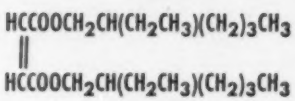

join Monsanto's "work-horse" monomers

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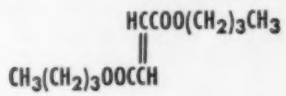

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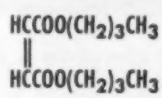
DIBUTYL MALEATE



Typical Products

acid esters
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clear coatings
copolymer emulsions
detergents
elastomers
fabric-sizing agents
fibers & free films
fumaramide
hydrocarbon stabilizers
ion-exchange resins
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succinates
surfactants
synthetic lubricants
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A MEMO TO MANAGEMENT

How to Increase Both Volume and Profit for 1962

The final quarter of every calendar or fiscal year is always spent looking forward to the next one. Management at all levels reviews what has happened and tries to forecast the future, based on the facts.

The facts clearly indicate that in 1962:

A. Competition will be tougher.
B. Prices will be as low or lower.
C. Supply will be as great or greater.

But also: A. Business in general will be better.
(A boom is forecast for the last half of 1962 by top economists)
B. Markets will be broader (i.e. more products, applications and end uses).
C. Acceptance of plastics as engineering materials is spreading to an increasing number of new applications.

What does all this mean to you? First, it means that if you want to succeed in 1962 you must plan your attack carefully. Since prices are depressed and profits are small, your best energy and sales effort must be spent with those customers who can *buy now* and in large volume.

In short, you must concentrate your marketing effort!

To do this, you must first remember that today's plastics processor companies number only 3,000*. Of this number, about 1,000 produce 75% of total volume. These companies require concentration because, in a boom, they will probably be responsible for more than 50% of the increased volume.

Another way of looking at it is that your biggest customers are sure to get bigger in a boom.

Your smaller customers will grow too, but in pounds consumed, or production capacity, this growth will not be equal to that of your biggest customers.

Finally, the end users, who are not yet processing their own materials, will convert, two or three companies at a time, to captive operations of their own. Most of them will start out being big consumers, because it will be their large plastics requirements that forced them into captive operations, rather than continuing to buy from custom processors. But here we have seen a definite trend toward end users buying existing facilities, fully staffed and equipped, rather than starting out from scratch. Naturally, the reins of purchasing and specifying power would not change hands in such an acquisition.

On the other hand, if an end user decides to install his own molding facility, who will run it? Chances are the top men will come from companies already established in processing plastics.

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- M&T Stannous Octoate
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- M&T Catalyst T-12
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VINYL STABILIZERS
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- Thermolite® Barium-Cadmium Stabilizers
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• BLOW MOLDIN

Here's proof that NRM extruders are making startling gains in acceptance by the industry's blow molders. Machines in service in January, 1961, when the ad on the opposite page first appeared, were producing at a rate in excess of 72 million pounds of blow molded products per year. Today, that production capacity has jumped to 195 million pounds annually . . . a gain of 123 million pounds, or 174 per cent in just nine months!

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OVER

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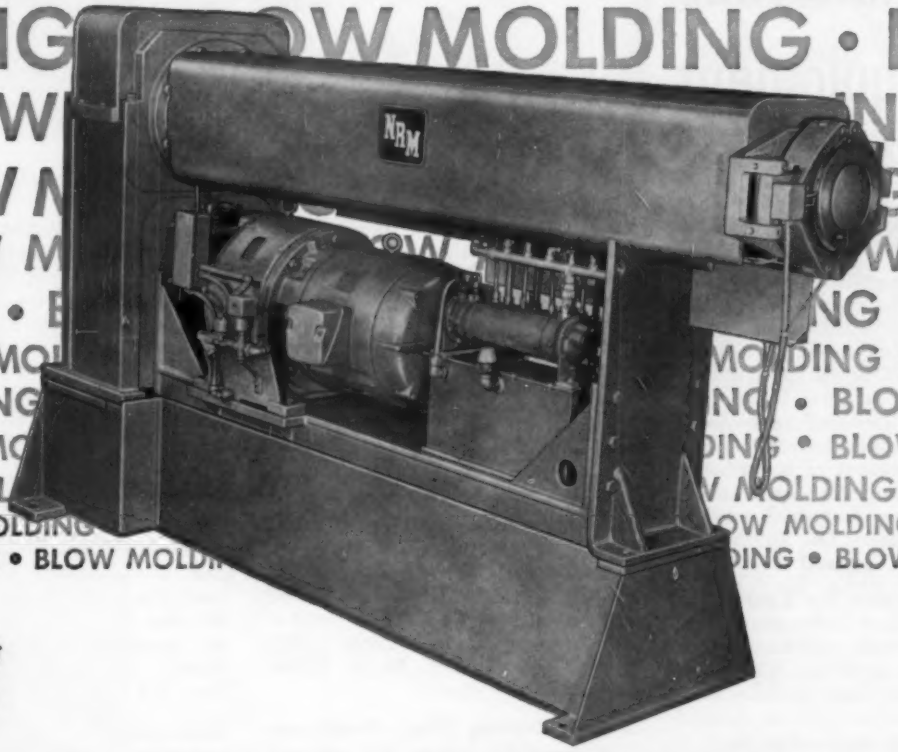

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New Materials and Equipment

So that you can get the information you want in the shortest possible time, we suggest you write directly to the company address listed at the end of each new product item.

MATERIALS AND APPLICATIONS

Plastic Packing for Water-Borne Wastes A new material, consisting basically of individual sheets corrugated in two directions, measuring approximately 36" × 21" in a self-spacing design is now being produced. Called "Dowpac" (patented), it is a plastic packing for efficient and economical treatment of water-borne wastes in trickling filter applications. *Dept. SPE,* **Dow Industrial Service, Div., Dow Chemical Co., 20575 Center Ridge Rd., Cleveland 16, Ohio.**

Reinforcing Resin for Latex Use of a new, low-cost hydrocarbon resin emulsion, Piccopale A-55 Emulsion, is said to result in lower cost, higher tensile strength, improved modulus, elasticity and increased tack in uncured films at the 20% replacement level. It is compatible with all types such as GRS, SBR-2000, vinyl toluene, butadiene and natural rubber. *Dept. SPE,* **Arthur M. Patureau, Advertising Manager, Pennsylvania Industrial Chemical Corp., 3460 Wilshire Blvd., Suite 604, Los Angeles, Calif.**

Giant Plastic "Plug" The face of a ten-story outdoor advertising sign in Detroit uses 1,510 sq. ft. of cast acrylic plastic among other materials. The new sign is the tallest ever built for Detroit and stands as a "salute" to the motor industry. Information from *Dept. SPE,* **Rohm & Haas, Washington Sq., Philadelphia, Pa.**

Vinyl Gravure Inks "XCL" Grade inks, low in abrasive properties, said to extend the lives of gravure cylinders ten-fold, act like oils, lubricating the doctor blade as it passes over the rotating cylinder. They are available from stock. *Dept. SPE,* **Claremont Pigment Dispersion Corp., 39 Powerhouse Rd., Roslyn Height, L. I., N. Y.**

New Non-Toxic Stabilizers A new group of high-efficiency, low-odor, non-toxic stabilizers for use in all types of vinyl formulas including rigids are reported to provide for over-all stabilization. Containing calcium and/or zinc, they have been accepted for use by the U.S. Food & Drug Administration. *Dept. SPE,* **Ferro Corp., 4150 E. 56 St., Cleveland 5, Ohio.**

High Solvating Vinyl Plasticizer High-solvating power, fast-solvating action, are claimed by the manufacturer of a new vinyl plasticizer, Flexol Plasticizer RK-1, and reputed to be tailored to the requirements of vinyl flooring. *Dept. SPE,* **Union Carbide Chemicals Co., Div., Union Carbide Corp., 270 Park Ave., New York 17, N. Y.**

Epoxamine W-99 A new single-package modified epoxy spray baking finish, with reported improved handling characteristics over conventional epoxy systems, is now available. Supplied in a wide range of colors demanded by the automotive and appliance industries, as well as bronzeless bolds and pigmented metallics, it is also used as a clear spray or dip coating for the corrosion protection of metals. *Dept. SPE,* **Bee Chemical Co., Lansing, Ill.**

Cellulose Acetate Flake Improved Higher production rates are said to be possible with the development of an improved cellulose acetate flake by Du Pont Company's Explosives Dept. The conversion of this flake into molding and extrusion compounds for the plastics industry will be the work of Plastic Materials & Polymers, Inc., Hicksville, L. I., N. Y., with Du Pont participation consisting primarily of technical assistance. *Dept. SPE,* **E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.**

Paint for Polyolefins Available in a wide range of colors and metallics, a new coating, P-38, has been introduced for polyolefins. Having good adhesion, it is being used for toys and is reported to be a fast, touch-dry spray coating with good mar resistance and excellent flexibility. *Dept. SPE,* **Bee Chemical Co., 2700 E. 170 St., Lansing, Ill.**

Safety Measure An inexpensive plastic cover which fits over automobile radiator caps will protect service station attendants from burns. Adaptable, it fits most American cars and small trucks and is reusable. The polyethylene cap, made of "Alathon" can be "personalized." *Dept. SPE,* **E. I. duPont de Nemours & Co., Inc., Pub. Rel. Dept., Wilmington, Del.**

Unbreakable 13-Gallon Bottle A new powder molding process produces unbreakable 13-gal. polyethylene plastic bottles in one piece, providing a light and corrosion-resistant container for industry and home. Designed to replace heavy, bulky glass carboys, the new bottles of Microthene, trademark of National Distillers and Chemical Corp., will probably be made in sizes up to 55-gallons soon. *Dept. SPE,* **U.S. Industrials Chemicals Co., 99 Park Ave., N. Y. 16, N. Y.**

Tough Fiber Glass Lining Cargo and baggage compartments which necessarily must withstand tremendous impact loads may be lined with a new, tough fiber glass based on a patented weave pattern that eliminates interlacing of the structural yarns in the fabric. The special fiber glass laminate makes its debut in the new medium-range Boeing 727 and 707 jet transport *Dept. SPE,* **J. P. Stevens & Co., Inc. Stevens Bldg., B'way at 41 St., N. Y. 36, N. Y.**

Evaluating Coated Paper A new Wet-Rub Tester is reported to provide a reliable method for quantitative evaluations of coated papers. The instrument and the associated test procedure are said to exhibit exceptional repeatability. *Dept. SPE,* **Thwing-Albert Instrument Co., Penn St. & Pulaski Ave., Phila. 44, Pa.**

(Continued on page 1240)

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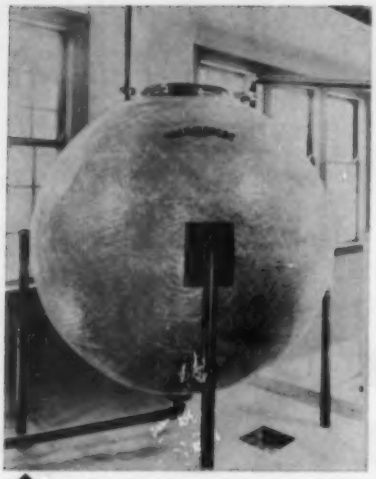

Reinforced Plastic Tank A unique low-cost, lightweight spherical tank fabricated from a glass-reinforced Bisphenol A polyester has been developed as a processing or storage unit for the paper, chemical, textile, metals, petroleum and agricultural industries, where corrosive conditions necessitate a structure with high chemical resistance. *Dept. SPE,* **Justin Enterprises, Inc., 3755 Edwards Rd., Cincinnati 9, Ohio.**

New Primary Plasticizer Designed to meet the rigid service requirements of high temperature wire insulation, Truflex 300 claims particularly low volatility, excellent retention of physicals after prolonged heat aging, inherent resistance to moisture, and outstanding electrical properties. It blends readily with polyvinyl chloride resins and is compatible with practically all other plasticizer types. Application is not limited to electrical field, according to the manufacturer. *Dept. SPE,* **Thompson Chemical Co., Pawtucket, R. I.**

Coaxial Cable Insulation A new series of cellular, irradiated polyolefin insulating materials for coaxial cable has been developed. The new dielectrics have been designed to impart to coaxial cable a combination of superior heat resistance and toughness with low capacitance and reduced attenuation, according to the developer, and are said to be of special value where space and weight savings are important. *Dept. SPE,* **Mr. D. Sahud, Radiation Materials Ind., 36-32 37 St., L.I.C.1, N. Y.**

EQUIPMENT

Rigid Urethane Foaming Machine Offering accurate reproducible ratio setting, a new rigid urethane foaming machine is available with exclusive annular pumps said to permit calibration of every machine to NAFIL formulations. Application is reputed to be in almost any operation where insulation is used in the product or in processing and handling the product to insulate, cushion, provide buoyance, etc. Free literature is available immediately. *Dept. SPE,* **Chase Chemical Corp., 3527 Smallman St., Pittsburgh 1, Pa.**

Automatic Bag Sealer Reputed to seal up to 80 bags/minute, permitting easier neater and faster bag opening, a new automatic bag sealer, adaptable to all types of polyethylene bags as well as some of cellophane and cloth, has been introduced. The new machine handles bags up to 19 pounds in capacity. Machine adjustment for different size bags, not necessary except in weights below three pounds. *Dept. SPE,* **Minnesota Mining and Manufacturing Co., St. Paul, Minn.**

New Panel Instruments Rectangular A-C and D-C meters with new 3½" instruments have been made available as part of the Weston 1900 Series. They can be had as ammeters, milliammeters, microammeters, and voltmeters, with optional 1% or 2% accuracy. Superior readability and illumination result from large windows on the front meters. *Dept. SPE,* **Daystrom, Inc., Weston Instruments Div., Newark, N.J.**

Plastics Welding Kit Designed for training of welders, and maintenance and repair of plastic-fabricated products, a new "kit", complete with steel carrying case, has been made available. Details on Model 15-TM, *Dept. SPE,* **Kamweld Products Co., Norwood, Mass.**

Laboratory Scale Film Stretcher Fifty, four-inch square samples can be stretched uni and bi-axially by an automated operation per hour. The effects of all combinations of the physical properties can be determined in the laboratory and plant machinery loads predicted. Information and brochure: *Dept. SPE,* **T. M. Long Co., Somerville, New Jersey.**

Marking Polyethylene Bags A new hot transfer leaf printer, reported to apply sharp, clear, indelible imprints on polyethylene bags has been introduced. A solenoid-controlled, air-operated unit, it uses heated metal type and a hot printing head to permanently transfer the thermoplastic die imprint from a roll of a tape to the bag. *Dept. SPE,* **Industrial Marking Equipment Co., Inc., 655 Berriman St., Brooklyn 8, N. Y.**

Combination Molding Press Requiring the labor for just one press, a new type back-to-back hot and cold molding press combination has been designed that is fully automated from loading to unloading. Consisting of a 450-ton hot press and a 100-ton cold press engineered in tandem, it molds laminated plastics, rubber, grinding wheels, plywood and any material requiring a heating and cooling curing cycle. *Dept. SPE,* **Birdsboro Corp., Birdsboro, Pa.**

Injection Mold Circulator Redesigned The improved model, insulated tank, high heat circulator, for maintaining injection molds at temperatures from 200 to 350°F, features a relocated 23 GPM Pump and Partlow Controller with a top setting of 400°. Heating capacity is said to be trebled, from 3000 to 9000 watts. Built-in automatic cooling, too. *Dept. SPE,* **Injection Molders Supply Co., Inc., 17601 So. Miles Rd., Cleveland 28, Ohio.**

Mix 'n Spray Gun Turvort, a new unit for mixing and dispensing reactive resins and hardeners has been incorporated into an easily handled, one-pound gun. When fed from a metering system, it mixes and sprays reactive resins, and when equipped with proper spray tips, handles airless spraying of multicomponent resin materials. *Dept. SPE,* **Leal Corp. P. O. Box 53, Oaklyn, N. J.**

MANUFACTURERS' LITERATURE

From Acrylics to Zein The plasticizing of resin coatings is covered in graphic detail in a new 54-page technical bulletin: "Plasticizers in Protective Coatings." Ten tables of comparative evaluations, 150 suggested starting formulations for 19 different types of cellulosic, rubber, vinyl and other resin coatings, are contained in this extensive application work. *Dept. SPE,* **Organic Chemical Div., Monsanto Chemical Co., 800 N. Lindbergh Blvd., St. Louis 66, Mo. Att.: Mr. R. Hogan.**

Aqueous Foil Laminating Adhesives An eight-page, 6,000 word report incorporating a complete discussion on the physics of foil bonding, including mechanical attachment and polar adhesion, required adhesive properties for foil applications, and analysis of currently-used foil adhesives, including neoprene-casein, butadienestyrene, and nitrile latices, vinyl resins and acrylic polymers, has been published. Write, *Dept. SPE,* **The Borden Chemical Co., Dept. H., 350 Madison Ave., N. Y. 17, N. Y.**

(Continued on page 1243)

EVALUATION OF BRITTLE FAILURES OF POLYETHYLENE

Polyethylene may fail at unusually low stress levels when exposed to certain surface active agents. These failures, commonly called stress cracks, are usually characterized by sharp conchoidal fractures in regions of the article that have been subjected to relatively high levels of sustained polyaxial stress.

One method of testing brittle failure provides a means of controlling reproduction of conditions typical of field failure. This method makes use of a specimen of polyethylene cut in the shape of a Maltese cross (Fig. I), which is stressed biaxially. Test environment is applied to both the upper and lower surfaces of the specimen center. Time from initial exposure to the reagent to initiation of cracking is recorded as the independent variable. This test method provides for control of the significant variables, and eliminates the factor of creep. It also eliminates premature failure due to edge imperfections.

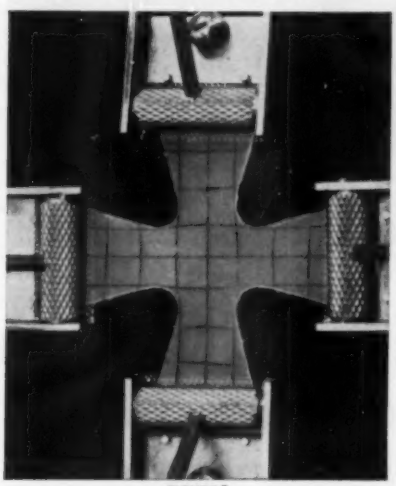

FIGURE I

In this study of factors which might influence the useful life of polyethylene, the environmental variables of stress and temperature and the material variables of density and melt index were found to be significant.

As expected, stress level was found to be important in determining failure time. It is equally important that this stress be uniform throughout the test, and be unaffected by secondary influences such as creep.

A significant interaction was found between temperature and melt index. Though the effect of temperature on test results is as expected, the influence of the interaction should be considered in any attempt to accelerate results by elevating test temperatures.

Reagent concentration has a definite effect on failure time, but only in the concentration range in which interfacial tension between reagent and specimen is changing. Above this range, increasing concentration has little effect on failure time. For example, data for all concentrations above 3% reagent in water fall on the 100% curve.

Figures II, III and IV illustrate the influence of melt index on failure time of polyethylene specimens of varying densities. In low density materials, the effect of melt index is very pronounced. In fact, materials with densities of 0.916 and melt indices of less than 8.0 do not show brittle failures in reasonable periods of time by this method. When the stress level is increased on such materials, ductile failure occurs before brittle failure begins. Thus, the transition in the mode of failure for such materials is in the room temperature region.

Full details and data on the study, of which this is only a partial report, are available on request by designers and plastic engineers. Dow Plastics Technical Service Engineers are engaged in continual studies on all aspects of finishing, molding and design of plastics parts. For information, write THE DOW CHEMICAL COMPANY, Midland, Mich., Plastics Sales Department 1735EX11.

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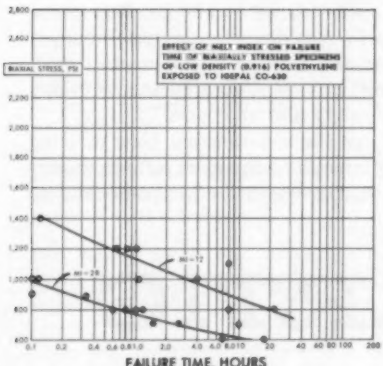

EFFECT OF MELT INDEX ON FAILURE TIME OF BIAXIALLY STRESSED SPECIMENS OF LOW DENSITY (0.916) POLYETHYLENE EXPOSED TO IGEPAL CO-630
BIAXIAL STRESS, PSI
MI = 29
MI = 12
FAILURE TIME, HOURS

FIGURE II

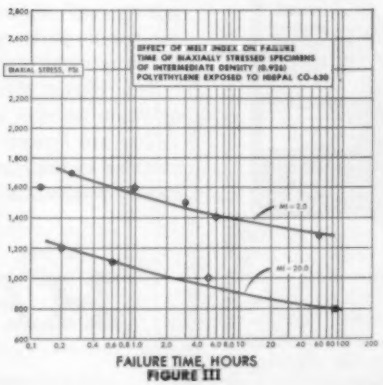

EFFECT OF MELT INDEX ON FAILURE TIME OF BIAXIALLY STRESSED SPECIMENS OF INTERMEDIATE DENSITY (0.926) POLYETHYLENE EXPOSED TO IGEPAL CO-630
BIAXIAL STRESS, PSI
MI = 2.0
MI = 20.0
FAILURE TIME, HOURS

FIGURE III

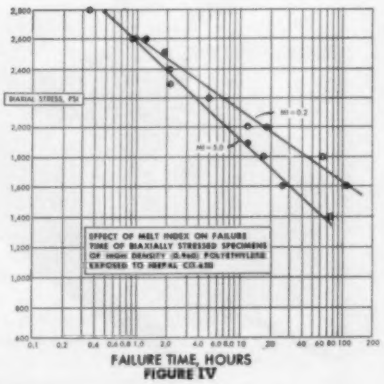
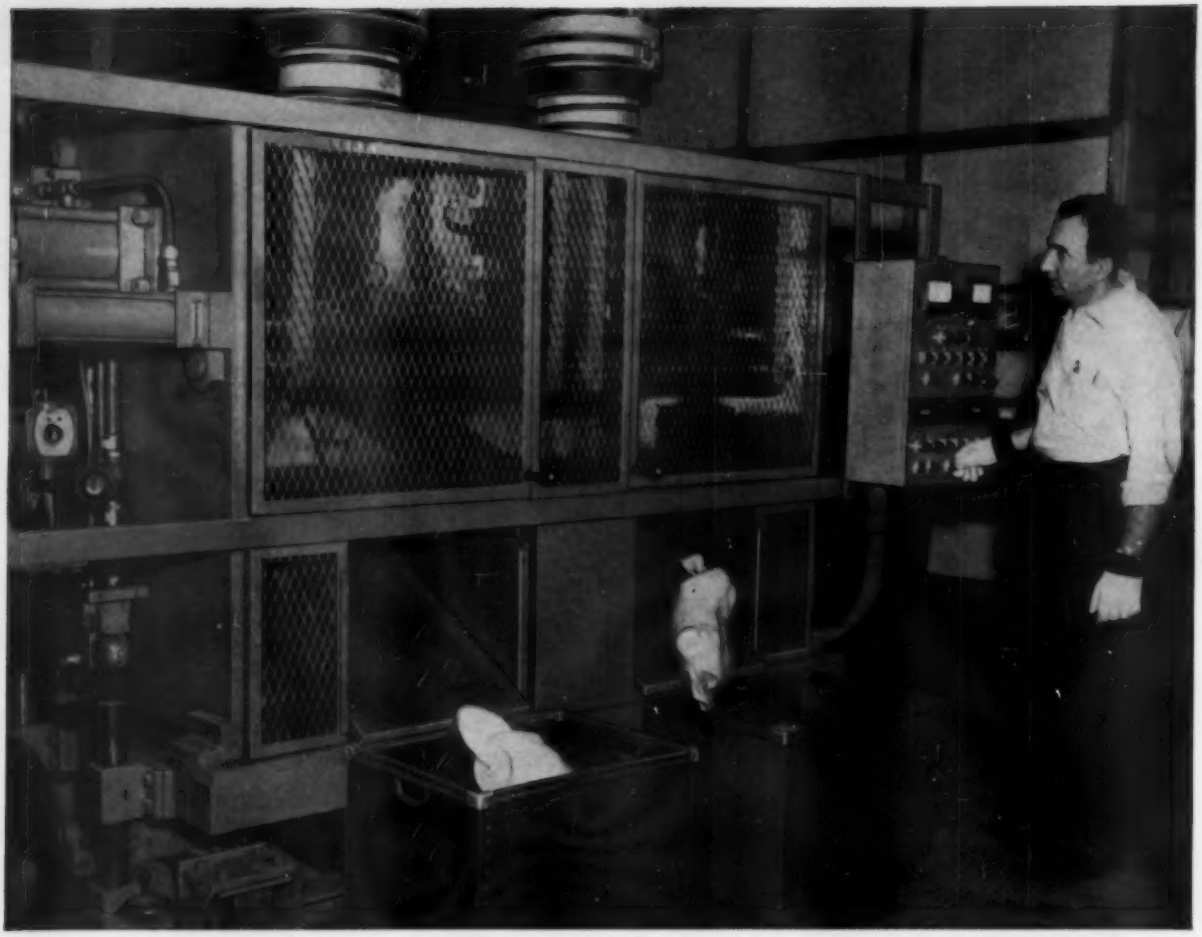
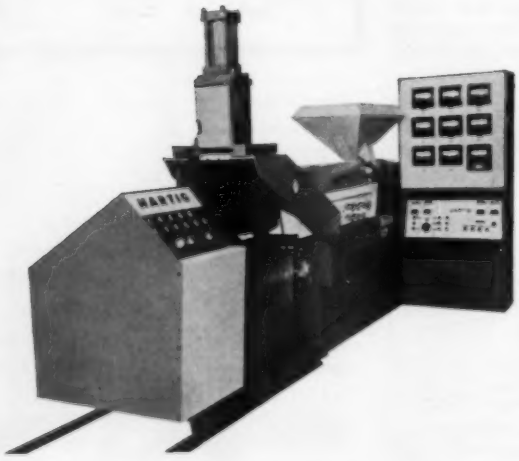

EFFECT OF MELT INDEX ON FAILURE TIME OF BIAXIALLY STRESSED SPECIMENS OF HIGH DENSITY (0.960) POLYETHYLENE EXPOSED TO IGEPAL CO-630
BIAXIAL STRESS, PSI
MI = 0.2
MI = 5.0
FAILURE TIME, HOURS

FIGURE IV

THE DOW CHEMICAL COMPANY DOW Midland, Michigan



New Hartig blow molding press



in action at Ideal Toy. Shown above is one of the new Hartig blow molding machines producing doll bodies. Operation is continuous and automatic; output is of high quality and uniform; maintenance is simple. This press can handle parts up to 17-inch diameter, is track-mounted for easy mold changes and extruder maintenance.

The Hartig extruder with ram/accumulator provides optimum parison uniformity and shot size.

You are invited to use the experimental blow molding machine in the Hartig laboratory shown at left for experimental production of your parts. Write for specifications.

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MANUFACTURERS' LITERATURE

(*Continued from page 1240*)

Vacuum Metalizing Widening use of vacuum metalizing, a simple, clean, low-cost method of depositing a thin layer of metal on prepared surfaces of metal, glass, paper or plastics to yield either a functional or a decorative coating, is said to be rapidly supplanting other metal-finishing procedures on a wide variety of products. The specifics in a new brochure, Bulletin 584. *Dept. SPE,* **F. J. Stokes Corp., 5500 Tabor Rd., Phila. 20, Pa.**

Automatic Screen Process Printing Machinery All types of automatic and semi-automatic equipment with speeds up to 10,000 impressions/hr. for screen process printing on flat, round, cylindrical or conical objects of all materials is catalogued in a new 68-page bulletin. *Dept. SPE,* **American Screen Process Equipment Co., 706, 1439 W. Hubbard St., Chicago 22, Ill.**

ACIL Directory The 8th Edition of the ACIL Directory is now available to industrial and government executives. *Dept. SPE,* **Executive Secretary, ACIL, 4302 East-West Highway, Washington 14, D. C.**

Plastics Services and Products An outline of the services and products offered in the laminated, fabricated and molded laminated plastics fields is contained in a new 12-page brochure, fully illustrated. *Dept. SPE,* **The Richardson Co., 2634 Lake St., Melrose Park, Ill.**

Facts on Testing Physical testing of new developments in test instruments, methods, applications for test instruments, accessories, trends in testing research and development work are taken up in a new release. *Dept. SPE,* **Thwing-Albert Instrument Co., Penn St. & Pulaski Ave., Phila. 44, Pa.**

Sign Shop Handbook The construction of acrylic plastic signs is taken up in a profusely illustrated 92-page booklet dealing principally with the use of cast Plexiglas sheet in signs. Write for "Plexiglas Handbook for Sign Shops", *Dept. SPE,* **Rohm & Haas Co., Washington Square, Phila. 5, Pa.**

Adhesive Problems A listing of many new adhesives, coatings and chemical compounds for industrial applications is contained in a new, 12-page booklet. *Dept. SPE,* **Adhesive Products Corp., 1660 Boone Ave., N. Y. 60, N. Y.**

Pertinent Plastics Memo The "who, when, why and where" of molding compounds, fire-retardant resins and urethane foams have been taken up in a new eight-page booklet just published. Bulletin D400 is available through *Dept. SPE,* **Durez Plastics Div., Hooker Chemical Corp., North Tonawanda, N. Y.**

Teflon Products Featured A new bulletin covers the products and processing operations on fluorocarbon resin and on formulations containing reinforcing agents. The eight-page, illustrated publication is available from *Dept. SPE,* **Allegheny Plastics, Inc., Coraopolis, Pa.**

Mold Temperature Control Called the "Space Age" approach to Mold Temperature Control of plastics injection molds, vacuum forming molds, rolls, and extruders, a new handbook describes and illustrates the Thermolator. *Dept. SPE,* **Industrial Mfg. Corp., 31 E. Georgia St., Indianapolis 4, Indiana.**

Alkylated Phenols General physical and chemical properties, structural formulas and major uses and applications for four alkylated phenols: para-tertiary-butylphenol (PTBP); para-tertiary-amylphenol (PTAP); 2, 4-di-tertiary-amylphenol; and 2, 4-di-tertiary-butylphenol are described in a new bulletin. *Dept. SPE,* **Tar Products Div., Koppers Company, Inc., Koppers Building, Pittsburgh 19, Pa.**

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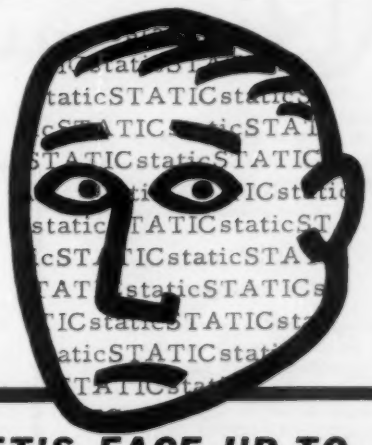

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James I. Powell—Personnel Manager,
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Over ten years experience in all phases of manufacturing management in plastics includes supervision, controls, scheduling and administration. M.I.T. degrees in chemistry and business. Achievements include cost reductions, productivity increases, new products. Desire challenging position with growth based on performance. Relocate. Box No. 304. SPE Journal.

MANUFACTURER'S AGENT

Seeks to represent in Michigan a reliable producer of thermoplastic resins for extruding and injection molding. Box No. 309, SPE JOURNAL.

CLASSIFIED INFORMATION AND RATES

SPE members in good standing are entitled to a total of three no-charge "Positions Wanted" advertisements within any 12-month period, each ad (not to exceed 50 words) should include training, experience, location desired; headline (not to exceed 3 words) must state job description. Additional words will be charged @ 25¢. *Do not* submit resumes: none are kept on file.

Last day for inserting all classified ads is the first day of the month preceding date of publication, except for display size ads which close on the 15th of month preceding issue date.

"Positions Open" and "Positions Wanted" —$12.50 per column inch, 2¼ inches wide. (35 characters per line; 7 lines per inch). Minimum charge: $12.50. Pre-publication contact, known as the "Availability File"—$5 service charge on "Positions Open"; no charge to SPE members. *See adjacent box for a description of how it works.* "Products and Services" and "Business Opportunities" —$20.00 per inch. Minimum charge: $20.00.

All ads include one bold face caption line. Additional caption lines @ $2.50 extra per line. Boxed ads (4-sided rule)—$3.00 extra. Agency commission allowed *only* on ads 5 inches or more in depth. Display ads of 1/16 page or more are charged at regular advertising space rates. No ¾ page or vertical ½ page ads published within Employment Service Guide section. Typesetting (non-commissionable) will be charged at cost.

HOW OUR "AVAILABILITY FILE" WORKS

If you are a company, or an SPE member who will be advertising in SPE JOURNAL, you can receive copies of those classified ads of potential interest to you *before* they are actually published in the Journal, provided that these advertisers have also indicated their interest in the same procedure. This pre-publication contact is what we call our "Availability File". All you have to do to participate is to sign the return postcard we send you upon receipt of your advertising insertion. When your card is returned, the ads are sent to you as they come in, up to publication date.

INDUSTRIAL ENGINEER, PLASTICS

Education and experience: Industrial Engineering, Plant Layout, Business Administration, Organization Planning, Supervisory Training, Labor Relations. Extensive experience in injection, compression, laminated, reinforced, vacuum molded plastics. Association includes activity as Plant Manager, Chief Engineer, Tool Engineer. Responsibility and authority required to obtain and justify adequate salary. Box No. 312, SPE JOURNAL.

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B.A.Sc. seeks responsible position with U. S. Company having or intending to organize a Canadian operation. 9 yrs. experience in production, technical service, development and sales in synthetic textiles, plastics, and reinforced plastics. Preference for small firm requiring creative ability and talent or providing means of acquiring a financial interest. Box No. 315, SPE JOURNAL.

EXTRUSION ENGINEER

Twenty years extrusion experience, supervision, production, process and product development, R&D, with vinyls, fluorocarbons, nylons, polyolefins, polyurethanes, etc. Technical service for sales, trouble shooting, design & construction of equipment, plant setup. No degrees. Resume on request. Will relocate, travel some. Box No. 320, SPE JOURNAL.

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Quick Delivery, Cheapest Prices

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Advertisers' Index

Allied Chemical Corp.,
National Aniline Div. 1138
Plastics Div. 1193, 1194, 1195, 1196
American Cyanamid Co., Plastics & Resins Div. 1191
Application Engineering Corp. 1176
Argus Chemical Corp. 1198
AviSun Corp. 1177, 1178, 1179, 1180, 1181
Cabot Corp. 1137
Celanese Polymer Co. 1156, 1157
Columbian Carbon Co. 1145
Collway Pigment Div., General Aniline & Film Corp. 1220
Curtiss-Wright Corp., Princeton Div. 1133
Davis-Standard 1152
D-M-E Corp. 1186
Dow Chemical Co.,
Coatings 1185
Molding Materials 1241
Eastman Chemical Products, Inc., Plastics Div. 1217
Emery Industries, Inc. 1136
Enjay Chemical Co., Div. Humble Oil & Refining Co.,
Chemicals 1144
Polypropylene 1148
Farrel-Birmingham Co., Inc. ..... Cover 4
Ferro Corp. ..... Cover 3
General Aniline & Film Corp., Collway Pigment Div. 1220
General Electric Co., Chemical Materials Dept. 1168, 1169
Gering Plastics, Inc., Div. Studebaker-Packard Corp. 1229
Goodrich-Gulf Chemicals, Inc. 1150, 1151
Harchem Div., Wallace & Tiernan, Inc. 1226
Improved Machinery Inc. 1171
Injection Molders Supply Co. 1216
Instron Engineering Corp. 1149
Lucidol Div., Wallace & Tiernan, Inc. 1227
Metal & Thermit Corp. 1235
Midland-Ross Corp., Waldron-Hartig Div. 1242
Mobay Chemical Co. 1222
Monsanto Chemical Co., Organic Chemicals Div. 1233
National Aniline Div., Allied Chemical Corp. 1138
National Distillers & Chemical Corp., U. S. Industrial Chemicals Co., Inc. 1141, 1142
National Lead Co. 1197
National Rubber Machinery Co. 1236, 1237
Olympia Tool & Machine Co. 1158
Plastics Engineering Co. 1140
Prodex Corp. 1172
Reichhold Chemicals, Inc.—Plastics 1146
Rohm & Haas Co.—Plastics 1170
The Simco Co. 1243
Standard Tool Co. 1225
Sterling, Inc. 1190
Studebaker-Packard Corp., Gering Plastics, Inc., Div. 1229
Union Carbide Plastics Co., Div. Union Carbide Corp. ..... Cover 2
U. S. Industrial Chemicals Co., Div. of National Distillers & Chemical Corp. 1141, 1142
Wallace & Tiernan, Inc.
Harchem Div. 1226
Lucidol Div. 1227
Waldron Hartig, Div. Midland-Ross Corp. 1242
West Instrument Corp. 1134
Whitlock Associates, Inc. 1143

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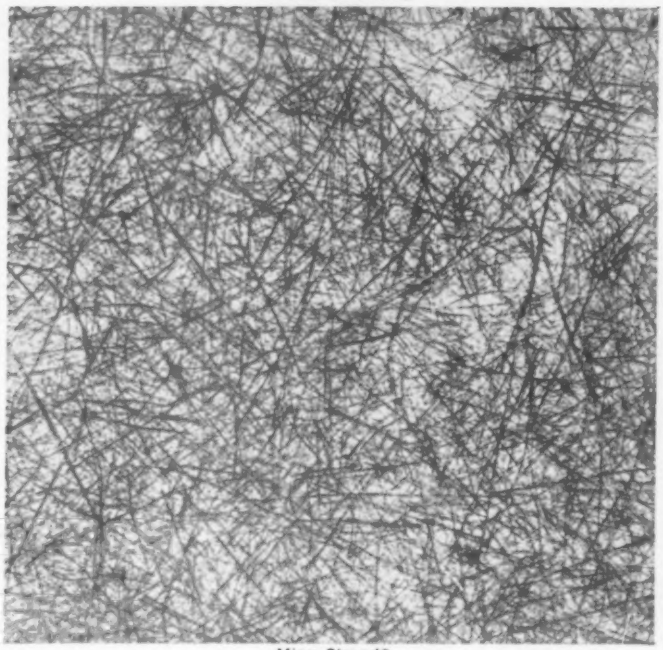

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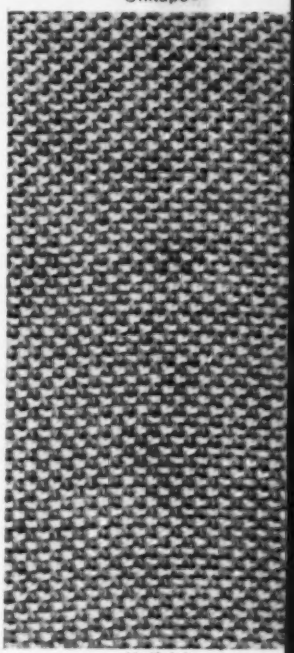

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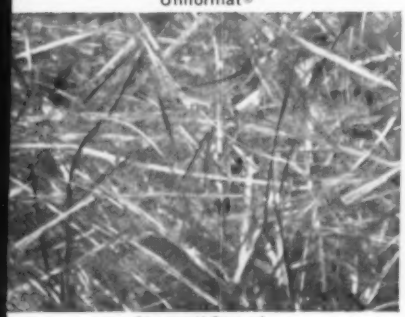

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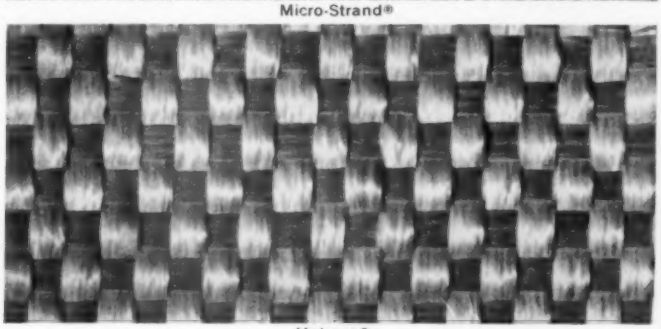

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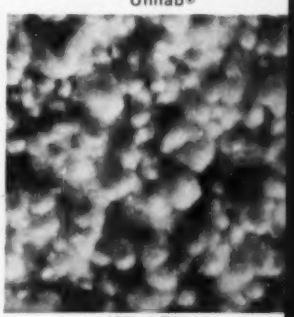

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- Contamination and cleanout reduced to a minimum.
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- Lower, less-destructive temperatures used in drying.
- Final product temperature close to air temperature.
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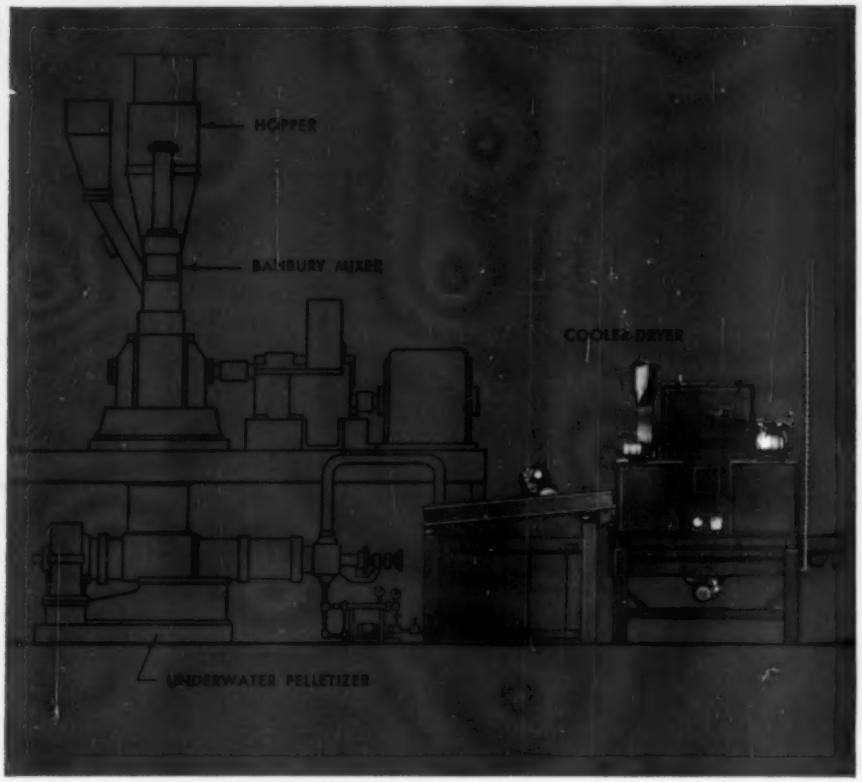

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for Polyolefin and PVC pellets

Specialists in the development of completely integrated lines for the rubber and plastics industries, Farrel now presents an outstanding new cooler-dryer.

Designed for greater processing efficiency, the unit handles the discharge of polyolefin pellets extruded through a Farrel underwater pelletizing head. The design is based on a new development in high-velocity jet drying; capacities range from 1,000 to 12,000 pounds per hour.

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At the end of the dewatering screen the pellets enter a discharge spout, attached to the drying section inlet by a flexible boot. A stainless-steel vibrating pan conveys the pellets along its length. Within this drying zone, air is heated and pressurized before being expelled upon the agitated pellets. Circulated air is blown through jets in a pattern above the product bed and impinges on the product at speeds of from 3500 to 10,000 feet per minute. This high velocity air causes the pellets to "boil," thus exposing the entire surface of each to the air. At the discharge end of the drying section, the pellets pass over a sizing screen which separates any "overs" from the product.

Send for details of this new product from Farrel.

FARREL-BIRMINGHAM COMPANY, INC.
ANSONIA, CONNECTICUT

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*Patent pending.

FB-1222